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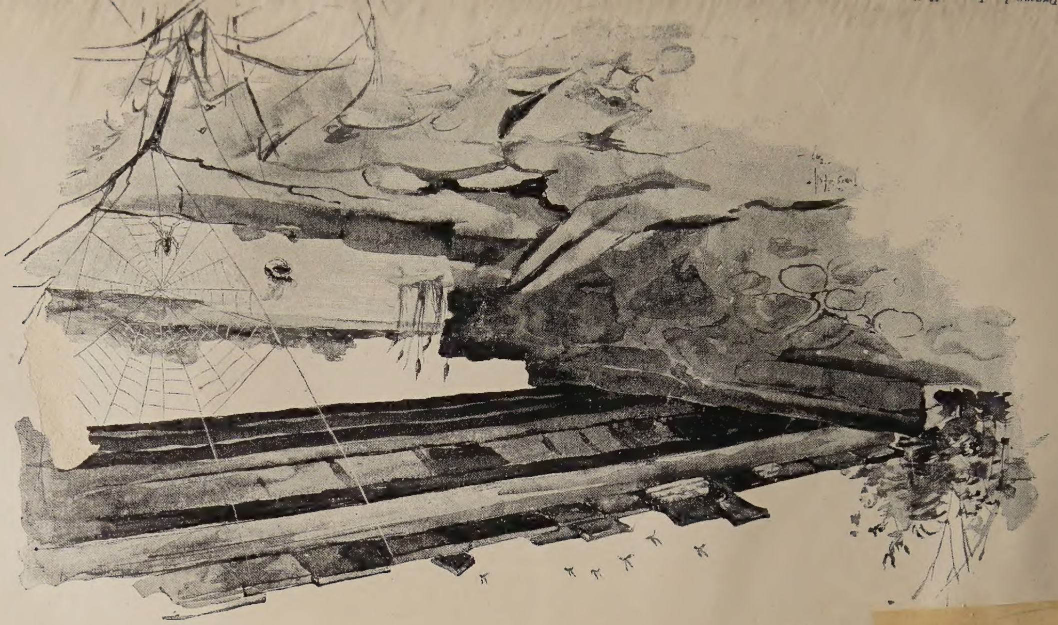

LIFE HISTORIES

OF

AMERICAN INSECTS

BY

CLARENCE MOORES WEED, D.Sc.
Professor of Zoölogy and Entomology, New Hampshire
College of Agriculture and the Mechanic Arts

With 21 Full-page Plates and many Figures in the Text

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To

Professor Albert J. Cook

TEACHER AND FRIEND

PREFACE

In the following pages I have attempted to discuss in a non-technical manner the life histories of a few of the most interesting American insects. Many of these are species or groups of species which I have especially studied during the last ten years; but in the case of nearly all the sketches I have drawn freely for facts upon the published writings of my fellow-entomologists. It is here impracticable to give individual credit in all cases; but I desire to make special mention of my indebtedness to the writings of the lamented Dr. C. V. Riley, and to those of Messrs. Comstock, Forbes, Howard, and Pergande. I am also indebted to the editor of *Appleton's Popular Science Monthly* for the privilege of republishing the first sketch of the series, and to the editors of the *Journal of Education* and *Psyche* for similar favors regarding certain of the others. I have also included a few paragraphs previously issued by me in the *Report of the State Entomologist* of Illinois and the *Bulletins* of the Experiment Stations of Ohio and New Hampshire.

The original authors to whom should be credited the illustrations which have not been first published by myself, either here or in previous publications, are indicated in the lines under the figures. For the privilege of obtaining duplicate electrotypes of these figures I am indebted to Messrs. Houghton, Mifflin, & Co., Mrs. C. V. Riley, Professor J. B. Smith, the Division of Entomology of the U. S. Department of Agriculture, and the Ohio and New Hampshire Experiment Stations.

C. M. W.

New Hampshire College of Agriculture and the
Mechanic Arts, Durham, 1 May, 1897.

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A FAMILY OF WATER-KINGS

Plate II. — The Haunt of the Belostomas.

A FAMILY OF WATER-KINGS

THERE is, perhaps, no way in which one may obtain a more vivid idea of the intensity of the struggle for existence among organic beings than by the study of the inhabitants of a fresh-water pond of long standing. Every inch of space in such a situation is teeming with life, both animal and vegetable, and the chief delight of most of the animals present is to wage a ceaseless warfare upon their weaker fellows. It is an aquatic rendering of Edwin Arnold's aërial drama: —

> ". . . Then marked he, too,
> How lizard fed on ant, and snake on him,
> And kite on both; and how the fish-hawk robbed
> The fish-tiger of that which it had seized;
> The shrike chasing the bulbul, which did hunt
> The jewelled butterflies; till everywhere
> Each slew a slayer and in turn was slain,
> Life living upon death. So the fair show
> Veiled one vast, savage, grim conspiracy
> Of mutual murder, from the worm to man,
> Who himself kills his fellow."

The largest insects occurring in our fresh-water ponds are the giant water-bugs — a family of peculiar creatures, armed with immense front legs fitted for grasping and clasping their victims, and a piercing, dagger-like beak which serves both to strike the prey and as a sucking tube to extract its juices; it also appears to be provided with poison glands which make more sure the effect of every thrust.

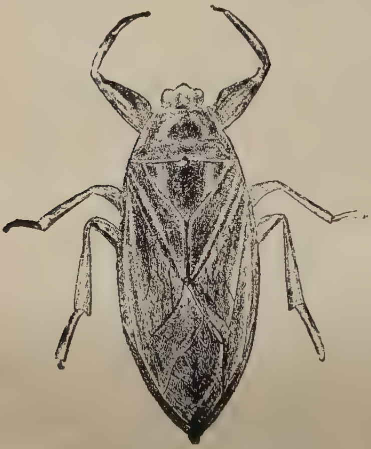

FIG. 1. — The American Belostoma.

Three species of these insects occur in the northern United States. Two of them are very large and closely resemble each other; the third is much smaller, being less than half the size of the others. The commoner of the larger ones in the more northern states is represented natural size in Fig. 1. It is called by entomologists *Belostoma americanum*, or the American Belostoma. It is brown in color, with leathery wings overlapping each other on its back, thick legs, along the sides of which are fringes for swimming, and a flat, boat-shaped body which offers little resistance to the water.

The eggs of the American Belostoma are deposited on pieces of wood or reeds along the margins of ponds, apparently where they will be wet but generally not directly in the water. They are laid in clusters, with from forty to sixty or more eggs in each. The eggs themselves are about one-fifth of an inch long, oblong-ovate in form, with the general color brown spotted with black; they are lighter colored below than above, and there is a whitish crescent near the top with a distinct black spot in its apex. This crescent indicates the margins of a little cap which comes off when the young bugs hatch.

Little seems to be known concerning the early history of these bugs. They probably crawl into the water soon after hatching, and live upon such aquatic insects as they are able to catch. I do not know just how fast they grow, but presume they become full-grown in a year. During the earlier period of their existence they have no wings; they are then in what naturalists call the nymph state. Their appearance just before they become adult is represented in Fig. 2. It will be seen that they have no wings, but otherwise they very much resemble the full-grown bugs. Finally, the skin splits open along the middle of the back, and the insect crawls out of its old skin clothed in a new one which is provided with wings. Now for the first time it can leave the pond where it has developed, and fly away to other bodies of water.

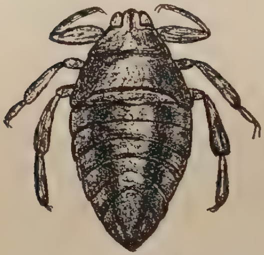

FIG. 2.—Last Stage of Nymph.

If the front leg of a full-grown American Belostoma be examined carefully, there will be found on the front margin of the long joint nearest the body a longitudinal groove for the reception of the next joint. By this character the present species can always be distinguished from the other one, in which there is no groove. This latter insect is called *Benacus griseus*. It is usually a little larger and darker colored than its American cousin, and apparently is more common southward than at the North. The life histories of the two species, as far as we know them, appear to be very similar. The eggs of the Southern form are laid in masses on sticks or other rubbish at the margins of ponds. The general color of recently laid specimens is greenish brown, with longitudinal stripes of darker brown, and a faint indication of a light crescent near the top. Their bases are glued to each other and to the stick on which they are deposited by a mucilaginous substance. An idea of the appearance of these eggs may be obtained from Fig. 3.

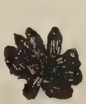

FIG. 3.—Eggs.

In South America a still larger species is found; it is called *Belostoma grande*, or the Great Belostoma. Still other species occur in Central America and Cuba, China and India, Egypt and Africa, but none are found in northern Europe.

Wherever these bugs appear they are formidable enemies of small fishes, frogs, and other aquatic animals. Of the *Benacus griseus*, Professor Uhler writes: "Developing in the quiet pools, secreting itself beneath stones or rubbish, it watches the approach of a mud-minnow, frog, or other small-sized tenant of the water, when it darts with sudden rapidity upon its unprepared victim, grasps the creature with its strong, clasping fore legs, plunges its deadly beak deep into the flesh, and proceeds with the utmost coolness leisurely to suck its blood. A copious supply of saliva is poured into the wound, and no doubt aids in producing the paralysis which so speedily follows its puncture in small creatures." In the breeding ponds of the Massachusetts Fish Commissioners these bugs destroyed so many young fish a few years ago that the authorities had to take special pains to catch and kill them.

In many localities these insects have lately received the popular name of electric-light bugs, because they fly so freely to electric lights. This indicates that in going from pond to pond they are nocturnal.

There is another species belonging to this family which is common throughout most of the United States. It is less than half the size of those I have been discussing, and is called by entomologists *Zaitha fluminea*, or the River Zaitha; and is also known as the Lesser Water-bug. It is a brown insect of the size and shape shown in Fig. 4. Its legs are provided with fringes for swimming, and it has a slender, sharp-pointed beak. As one would expect, it feeds on smaller animals than do the Belostomas. A few years ago I dredged a number of these bugs out of an Ohio pond, together with a great quantity of other forms of pond life, and placed them all in glass aquaria to study their feeding habits. The bugs seemed to feed most voraciously upon the larvæ or nymphs of dragon flies. These were captured continually, and their juices greedily sucked out. The next most abundant victim was the common Undulating Backswimmer (*Notonecta undulata*) shown in Fig. 5. In one aquarium, in which a large amount of pond material, including half a dozen Zaithas, had been placed, four of the latter were in sight at one time, each with one of these Backswimmers grasped in its front legs and the beak inserted in the body.

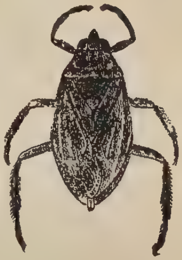

FIG. 4.—The River Zaitha.

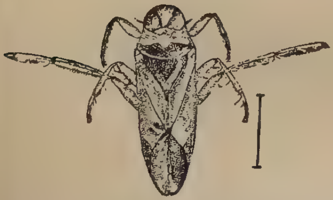

FIG. 5.—Undulating Backswimmer. Magnified.

Small fresh-water snails occasionally contribute to the diet of this insatiable creature, and young mayflies are also commonly eaten. Flying insects which fall upon the surface of the water are sometimes caught and killed.

The giant water-bugs are typical examples of the true bugs. They belong to the group called by naturalists *Heteroptera*, the members of which are characterized by having two pairs of wings, the front pair being thickened at the base and thin at the tip, and mouth parts fitted for sucking rather than for biting. During their development they do not undergo so complete a series of changes as do the caterpillars, which transform into butterflies, but grow more like the grasshoppers, the young resembling the adults in general appearance but having no wings. These bugs can be dipped out of ponds and ditches almost anywhere by means of a long-handled net, and are easily kept in small aquariums, where they form interesting objects for study.

THE TOOTHED-HORNED FISH-FLY

THE TOOTHED-HORNED FISH-FLY

THE family *Sialidæ* of the order Neuroptera contains comparatively few species of insects, but these are generally conceded to be of unusual interest. Just why this should be the case I know not, unless it is because the earlier stages are passed in brooks or streams, and the creatures are thus invested with the perennial interest that pertains to running water. To this family belongs

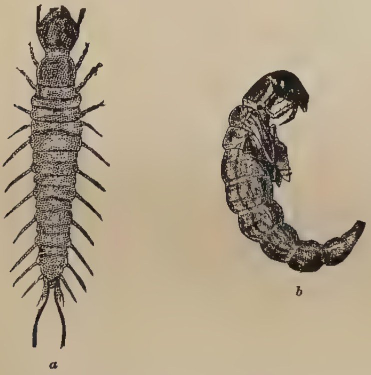

FIG. 6.—Fish-fly. *a*, larva; *b*, pupa.

the Horned Corydalus or Hellgrammite, whose larva — the fisher's Dobson — loves the splash of the tiny torrent of the brook or the more majestic swirl of the gleaming river. Here also are found several somewhat smaller insects — the fish-flies of the genus Chauliodes, to whose life history I desire to call attention.

He who by means of a long-handled net explores the bottoms of brook-side ponds, will sometimes bring to the surface peculiar larvæ resembling Fig. 6 *a*; they are about two inches long, with their general color dingy brown, and with blackish heads, each of the latter being furnished with two five-jointed antennæ and six simple eyes (*ocelli*), four of which are more distinct than the other two. Along each side of the body is a row of filaments, while in front, on the under surface, are six well-developed legs.

If one of these larvæ be placed in a small glass aquarium jar, its habits may be studied to advantage. It will eat living or dead insects of many kinds, including aquatic species, and flies or spiders which may happen to fall upon the water. The ordinary mode of locomotion is that of crawling along weeds and the débris of various kinds which gathers at the bottom of ponds, but when alarmed, the insect can swim rapidly by suddenly doubling the body up, bringing the head in contact with the abdomen, by which means it is propelled some distance through the water. These larvæ also have a peculiar habit of walking along the surface of the water, body downward; they can move quite rapidly in this manner. When handled, they occasionally eject from the mouth a considerable quantity of a blackish fluid, reminding one of the similar habit of certain locusts or grasshoppers.

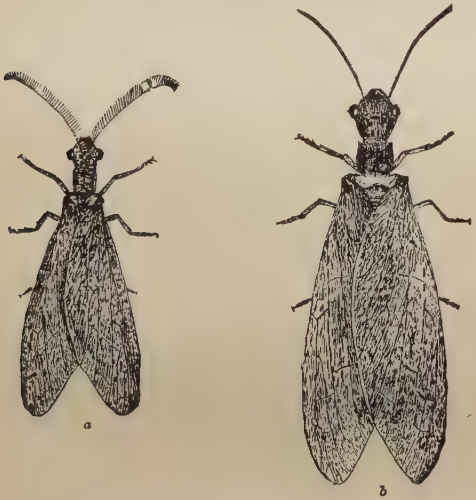

FIG. 7.—Fish-fly: *a*, male; *b*, female.

The fish-fly larvæ apparently prefer comparatively still waters rather than the tumultuous rapids chosen by the Dobson for its abode. I have been most successful in finding them in ponds beside rivers, or in the deep pools so often formed by the margins of brooks. When they become full-grown as larvæ they crawl upon the bank; if there are partially decayed logs thereon, they are likely to creep beneath the bark and form a cell in the rotting wood. Here they pupate, taking on the appearance of Fig. 6 *b*, and being dingy brown with a blacker head. The antennæ are curved over the eyes; the wing-pads are well developed; at the tip of the abdomen there are two robust appendages. About ten days later the pupa changes to the fully developed fish-fly, in which condition there is a decided diversity in the sexes. The females (Fig. 7 *b*) are the larger, with immense net-veined membranous wings and long slender antennæ. The males (*a*) are much smaller and have broadly feathered antennæ.

The larva leaves the water in early spring,—in the region of central Ohio near the first of April,—and the adults appear in May.

There are several species of these fish-flies. The one illustrated here is called the Toothed-horned Fish-fly, *Chauliodes rastricornis*.

TIGER-BEETLES AND THEIR LARVÆ

TIGER-BEETLES AND THEIR LARVÆ

FROM midsummer until late in autumn one can readily find along roadsides, as well as in gardens and ploughed fields, small holes, not quite so large as a common lead-pencil, extending vertically downward into the ground. By inserting a spade at one side and digging up the earth about such a hole, then carefully tracing the opening to its lower end, one will usually discover a curious-looking larva, having a large, brownish-black, flat head, with the upper part of the first segment behind the head also flat and shield-shaped, and the top of the next two segments with brown shield-like coverings; the remaining body rings are whitish, with two rows of brown spots along the back. Each of these abdominal segments is provided with tufts of moderately long, reddish-brown hairs, while on the back of the fifth segment there is a very curious hump, furnished with two peculiar, claw-like hooks; in front and behind the bases of these hooks there are tufts of hairs similar to but more numerous than the hairs on the other segments. The tip of the abdomen is furnished with a ring of stiff hairs, inside of which there is a peculiar extensile foot-like projection. On each of the three segments immediately behind the head, there is a pair of rather long brown legs, tipped with stout claws.

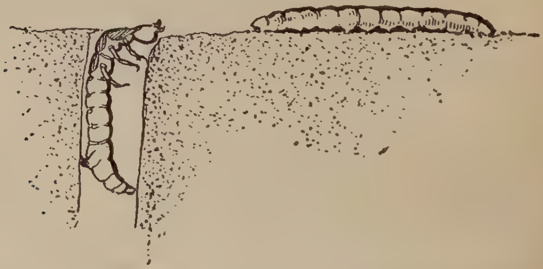

Fig. 8. — Tiger-beetle Larva in Burrow, with Cabbage Worm approaching.

The head itself is furnished with a pair of large, sickle-like jaws and other conspicuous mouth parts.

This extraordinary creature is the larva of a tiger-beetle. Early in summer it hatched from an egg deposited in the soil by a handsome, active beetle, and probably began at once the making of a burrow. As it became larger it either constructed a new burrow or enlarged its old one, using it as a lair into which to drag its unfortunate victims. It ordinarily lies in wait at the mouth of its burrow, its head projecting very slightly and its jaws expanded to grasp any crawling insect that comes within reach. When a caterpillar or other creature is thus caught, it is dragged down the burrow, where it is devoured at leisure. In my garden yesterday I saw a full-grown green cabbage worm (the larva of *Pieris rapæ* — the Imported Cabbage Butterfly) sticking halfway out one of these burrows. Digging away the earth, I found a tiger-beetle larva tugging at the head of the caterpillar in the effort to drag it out of sight. The caterpillar would certainly have formed a succulent meal for his tigership.

The whole structure of this queer larva is admirably adapted to the conditions of its life. The large, flat head fills the opening of the burrow; the jaws lie wide open, ready to snap upon the unsuspecting victim; the legs are adapted to digging and to holding on to the sides of the burrow. If you place a larva upon a smooth surface and observe it walk, you will see that while the first and third pairs of feet are used normally, the middle pair bend upward and for the most part are waved in the air, scarcely or not at all touching the surface upon which the insect is walking. The reason for this is obvious when you think of the condition in which the insect normally lives: in travelling up and down its burrow the first and third legs are applied to one side of the cylinder and the second legs to the opposite side, thus giving firm support. It is evident also that the peculiar abdomen is adapted to the same end; the hump on the back of the fifth segment, with its hooks and brushes of hairs, is to be applied to the back side of the burrow, while the hairs and extensile sucker-like foot at the tip of the abdomen are applied to the opposite side. The two long claws on the hump serve to hold the larva from being pulled out of the burrow in case it should catch any large insect that objected to being drawn into its pit of darkness, and should attempt instead to pull the bandit from his ambush.

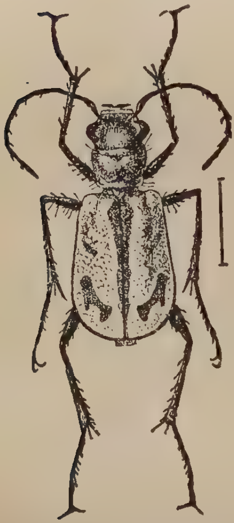

Fig. 9. — A Tiger-beetle. Magnified. (From *Insect Life*.)

The fully developed tiger-beetles are, for the most part, handsome and attractive insects. Concerning them Professor J. H. Comstock writes: "The graceful forms and beautiful colors of the greater number of the tiger-beetles have made this family one of the favorites of students of Coleoptera. To this family belong the most agile of all beetles; and they are not merely swift of foot, but are also able to fly well. They are found on bright, hot days in dusty roads, in beaten paths, and on the shores of streams. They remain absolutely still until we can see them well, but are yet out of reach; then, like a flash, they fly up and away, alighting several rods ahead of us. Before alighting they always turn so that they face us, and can thus watch our movements. Their popular name is suggestive of their predaceous habits, and of the spots with which many are marked. They are usually a metallic green, or bronze, banded or spotted with yellow. Some are black, and some that live on white sand are grayish white, being exactly like the sand in color."

The form and structure of a typical tiger-beetle are well shown in Fig. 9, which represents, somewhat magnified, a species (*Cicindela limbata*), often found in some sections of the United States. It is of the length indicated by the straight line at the right of the figure. It will be noted that the legs and antennæ are long; the head is distinct, with prominent eyes and large, sharply pointed jaws; the first division of the thorax and the wing-covers, as well, in fact, as all the body-members, have a very firm covering. Three other common species are represented natural size in Figs. 10 and 11.

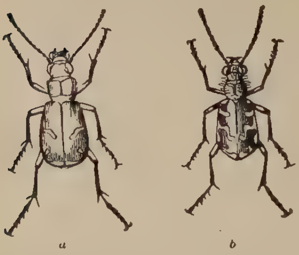

Fig. 10. — *a*, *Cicindela purpurea*; *b*, *C. hirticollis*. (After Riley.)

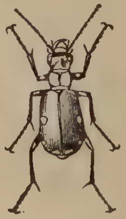

Fig. 11. — *Cicindela sexguttata*. (After Riley.)

Whether these larvæ have any serious enemies to contend with or not, I cannot say. They are wary creatures, retreating to the bottom of their burrows, which are often a foot deep, on the approach of danger, and apparently are safe from the attacks of birds. They must be somewhat exposed when they begin new burrows, though this is probably done at night. There is abundant opportunity for valuable scientific work in the study of the habits of these interesting larvæ, which can readily be kept in dishes or boxes nearly filled with earth. They may be fed with soft-bodied worms of many kinds; cabbage worms are easily available in summer and autumn; the large, white, wood-boring larvæ to be found in fallen logs have also been used to good advantage for this purpose. Some species of tiger-beetle larvæ apparently pass the winter in their burrows, pupating in them late in spring. They then soon change to adult beetles.

That these tiger-beetle larvæ are not confined for food to worms and grubs is shown by an interesting observation recorded by Mr. R. R. Rowley, of Missouri,[1] who writes: "In August, 1886, I made frequent excursions to damp places along a neighboring brook in search of butterflies. It was the droughty season, and there were but a few stagnant pools, damp gravel beds, and moist clay slopes at which insects could slake their thirst. At one of the last-named places I noticed a great bunch of yellow butterflies (mostly *Colias philodice*), and a few specimens of White Cabbage Butterflies (*Pieris rapæ*), which my advance started and put to flight. As a few individuals did not take to wing, but seemed unable to rise though they fluttered violently, my curiosity was aroused, and a closer investigation showed the bank and gravel bed below to be strewn with mutilated butterflies; scores of individuals, detached wings in some cases, in others the head and thorax remained intact. Upon taking the struggling butterflies by the wings, I found they were held firmly to the ground, their abdomens being drawn into the burrows of tiger-beetle larvæ. They were being actually eaten alive by these voracious grubs. I found that the robbers, after eating the softer parts of the butterflies, cast the wings and harder parts away from their holes. Upon my retiring a few yards, the thirsty butterflies returned and settled down to sip the moisture again. Those that alighted over the burrows were quickly seized by their cunning enemies, and the poor creatures could only flutter, unnoticed in their death struggles by their unsuspecting companions. I found the clay slope to contain great numbers of these holes or burrows, and the top of each hole displayed a dark head with a pair of ugly jaws; murderous assassins in hiding, thirsting for innocent blood."

---

[1] *Canadian Entomologist*, XXIII., 92.

The tiger-beetles form the family *Cicindelidæ*, of the order Coleoptera. They rank as the highest of all beetles, coming first in the scheme of classification. They may be found in almost any sunny situation, and early in summer I have seen them repeatedly making holes in the soil beneath boards in the garden, presumably for the purpose of depositing eggs.

THE CLICK-BEETLES

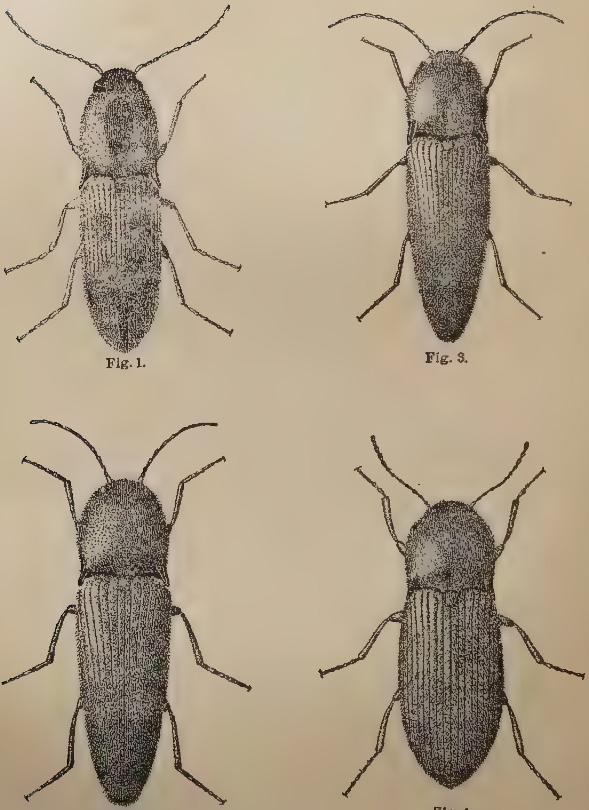

Fig. 1. Fig. 3.

Fig. 2. Fig. 4.

PLATE III.—FOUR CLICK-BEETLES. MAGNIFIED. (AFTER FORBES.)

FIG. 1.—*Drasterias elegans.* FIG. 3.—*Melanotus communis.*
" 2.—*Melanotus fissilis.* " 4.—*Agriotes mancus.*

THE CLICK-BEETLES

A LARGE proportion of entomologists begin the formation of their cabinets by collecting beetles. These insects are abundant and conspicuous, easy to catch, and require no special manipulation to prepare them for the cabinet. One of the first prizes which the young collector in our northern states is likely to get hold of is the large, grayish-black beetle called the Eyed Elater: it resembles the upper left-hand insect shown in Fig. 13, having a body decidedly flattened and two large, eye-like spots on the prothorax — the part just behind the head. When placed upon its back, the insect suddenly springs upward some distance, usually lighting upon its feet when it comes down.

This insect is the largest of our species of the interesting family of click-beetles, called by entomologists the *Elateridæ*. Nearly all the other members of the family are much smaller, and most of them are brown in color. They all have the power of springing upward when placed upon their backs, and their bodies are thin and flattened. Most of them appear to fly by night as well as during the day, and many of them may be found upon various flowers in which the nectar is easily accessible, sipping the sweet secretion.

The earlier stages of a number of click-beetles are passed in decaying wood, upon which the larvæ feed. The Eyed Elater and its allies of the genus Alaus are notable examples of this mode of development. The large yellowish larvæ, with brown heads and chitinous coverings of a similar color on the thoracic segments, frequently appear when a rotting log is pulled apart: two such larvæ are represented in Fig. 13. When full-grown, the larvæ pupate in an oval cell in the log or the earth beneath (Fig. 13, lower left-hand corner), and later emerge as adult beetles. Several years are believed to pass during the growth of the larva.

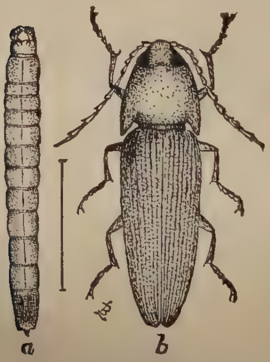

FIG. 12. — Click-beetle and Larva. Magnified. (After Bruner.)

There are several other species of click-beetles whose early stages are passed in decaying wood, but with a larger proportion of these insects the larvæ live in the soil and feed upon the roots of plants. Such larvæ are commonly called wireworms because of their cylindrical shape

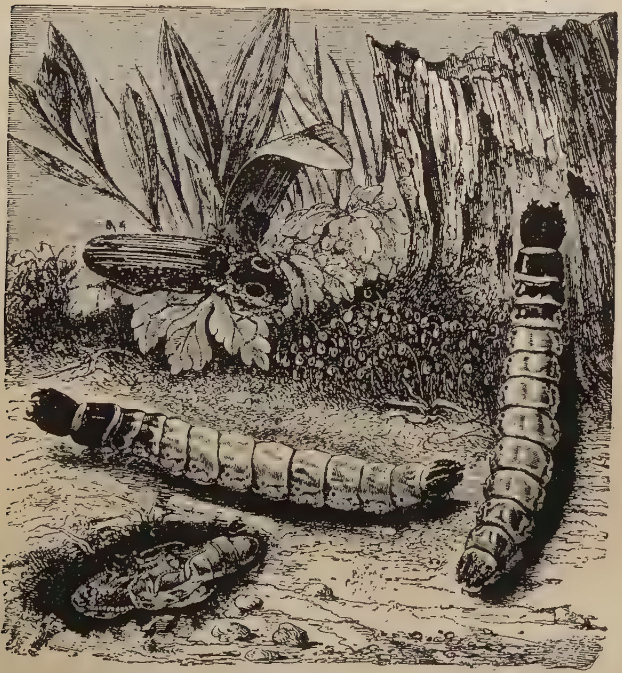

FIG. 13. — Three Stages of an Eyed Elater. (From *Riverside Natural History*.)

and hard, wiry structure; they are yellow in color, and pointed at each end. Consequently they can readily burrow through the soil in search of food. They appear to feed chiefly upon the roots of grasses, but also attack many other plants. When a meadow land, in which numbers of these wireworms are present, is ploughed and planted to corn or wheat, the latter crop is often seriously injured by the insects.

When full-grown, the wireworms pupate in oval cells in the soil, and in a few weeks change to click-beetles. The latter transformation commonly occurs late in summer or in autumn, and many of the beetles remain in the cells until the following spring before working their way to the soil surface. Some come out in summer and autumn, however, to pass the winter in sheltered positions. Eggs are laid by these beetles in the soil of grass lands. It requires two and perhaps three or more years for the larvæ to mature.

One of the commonest click-beetles is a small species called *Drasterius elegans.* It is represented, much magnified, in Plate III., Fig. 1; in this adult condition the insect is only one-fourth of an inch long, and is of "a general rusty-brown color, with black markings; the head, under side of abdomen, a large fusiform spot on the back of the thorax, a large oblong spot on the front portion of each wing-cover, and a wide sinuate band across the hind portion of the wing-covers are blackish; the antennæ and legs are yellowish-brown. The body is closely punctured and clothed with fine, short, incumbent, yellowish hairs. The wing-covers are striated by rather deep, oblong punctures, the intervening spaces nearly flat and minutely punctured."[1] The beetles pass the winter under boards and other shelter, having become mature late in summer. Apparently they deposit eggs in sod during autumn and spring, and the larvæ require two years to become full-grown. They are then yellow, and about half an inch long; when magnified they resemble Fig. 2, of Plate IV. Like most of the wireworms, the last segment of the body is peculiarly developed: the shape, projections, and markings of this segment in most wireworms are so peculiar that from its structure the species can generally be determined; some of the characteristic shapes which it assumes are shown in Plate IV.

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[1] Comstock and Slingerland.

The study of the life history of wireworms is attended with considerable difficulty. In order to watch them at work upon the roots of plants, Professor J. H. Comstock, of the Cornell University, has devised the ingenious breeding-cage represented in Fig. 14; it consists essentially of a narrow box having glass sides and an open top. This is filled with soil, a kernel of corn is inserted, and when it develops into a vigorous plant, the wireworms are introduced. The glass sides are covered with black rubber-cloth so that the larvæ will work near the glass; when desired, the cloth is removed and the wireworms may be seen at work.

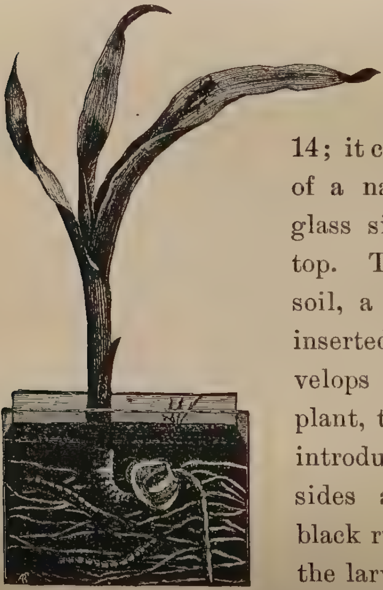
Fig. 14.—Breeding Cage for Wireworms. (After Comstock.)

The species known as *Melanotus communis* is one of the commonest click-beetles. This is the beetle represented, much magnified, in Plate

III., Fig. 3; it is uniformly brown in color, and about half an inch in length. Apparently the eggs are laid about the roots of grass, upon which the larvæ feed, living at least three years before completing their development. They change to pupæ in earthen cells about midsummer. "Soon after the cell is finished, the skin of the larva opens at the sutures on the top of the head, and along the median line on the dorsum of the following three or four segments. The white and tender pupa then works itself out, leaving the cast larval skin crowded into one end of the cell. The wing-pads, legs, and antennæ of the pupa are folded closely on the breast." About a month later the pupa becomes a beetle, which may remain in the earthen cell until the following spring before emerging to the outer world. In many cases, however, the beetles emerge in autumn and pass the winter under the shelter of logs and stones.

This variation in habit, with regard to the time of leaving the pupa cell, suggests an interesting study in natural selection. With several species there appears to be a similar variation: some of the beetles work their way above ground soon after maturing, while others remain snugly ensconced in the pupa cell until the following spring. Under natural conditions — that is, in regions were the soil is not disturbed by man — it would seem that the beetles in the cells would run less risk of elimination by birds or other enemies than those which were exposed to attack during autumn, winter, and spring. It is known that birds feed freely upon click-beetles, so that a real risk is run during the period of exposure. From this point of view, one would think that the action of the laws of natural selection would tend to foster the habit of hibernation in the pupal cell. It is also known that a considerable time is required for the tissues of the beetle to harden, so that those which remain long in the cells are likely to come forth in better condition than the others.

If disturbed when feeding on the nectar of flowers, the click-beetles commonly fall to the ground, where they remain motionless for some time, with their legs drawn tightly against the body. They thus are difficult to see, their dark-brown colors simulating the débris among which they have fallen. This is doubtless

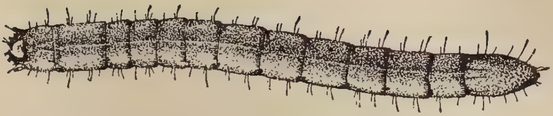

FIG. 1.

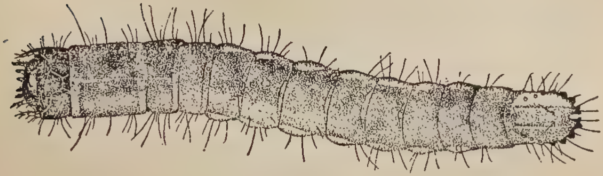

FIG. 2.

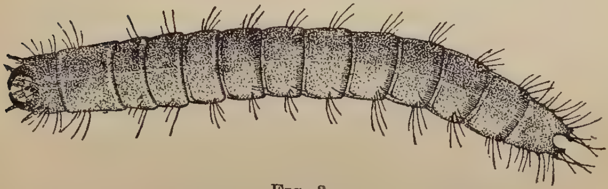

FIG. 3.

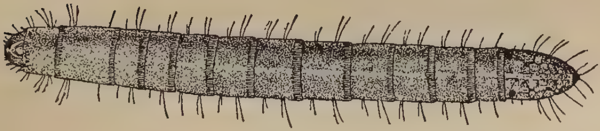

FIG. 4.

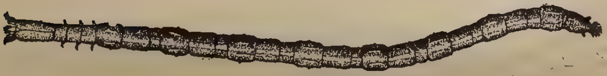

FIG. 5.

PLATE IV. — LARVÆ OF CLICK-BEETLES. MAGNIFIED. (AFTER FORBES.)

very useful in helping them to escape from birds.

The ability to spring upward when lying upon their backs enables them to regain their foothold when danger is past. There is a spine-like projection on the under surface of the hind margin of the prothorax, which fits into a groove on the front margin of the next segment behind. As Dr. Le Conte has explained, the jumping "is effected by extending the prothorax so as to bring the prosternal spine to the anterior part of the mesosternal cavity, then suddenly relaxing the muscles so that the spine descends violently into the cavity; the force given by this sudden movement causes the base of the wing-covers to strike the supporting surface, and by their elasticity the body is propelled upward." The 'click,' which is heard when these beetles spring upward, has doubtless given them their common name of click-beetle. The same habit no doubt is responsible for such other names as 'jumping-jacks,' 'skip-jacks,' and 'snapping-beetles,' which are often applied to them.

The male elaters are evidently attracted to the vicinity of the females by scent. One cloudy afternoon in 1896, while strolling along the border of an open grove in New Hampshire, my attention was attracted by a dozen or more click-beetles flying about a clump of grass. A careful examination soon revealed a female of the same species in the grass, with several males around her.

THE BLACK CRICKETS

THE BLACK CRICKETS

No autumn insects are more familiar than the black crickets which abound in every pasture from late summer until winter sets in ; even then they occasionally are to be found huddled together under boards and beneath the bark of stumps. They are insects which may easily be kept in-doors, and which will repay a little careful observation. Place them in tumblers, glass cans, chalk-boxes covered with glass, or any other

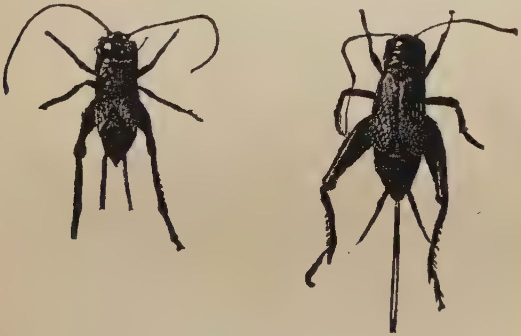

FIG. 15.—The Black Cricket. (From Smith.)

convenient receptacle, first covering the bottom with an inch or more of moist earth. Give them pieces of apple or leaves of clover to eat. Then keep them where you can see them easily, and you will learn much about their habits and life histories.

The general external anatomy of the cricket is easily traced. The large, nearly square head bears on each upper front corner a good-sized compound eye; between these there are several small simple eyes or ocelli, appearing as minute, white, circular spots against the dark background of the head. Directly in front of each eye toward the median line arises one of the long, slender, tapering antennæ, having a large basal joint, with the rest of the joints appearing under a lens as short, slightly swollen cylinders.

The mouth parts are very similar to those of the grasshopper, and may easily be dissected out to show the large labrum or upper lip in front, the mandible or jaw on each side, with the maxilla directly beneath. The labium or under lip together with the labial palpi and the maxillary palpi are very distinct. Directly back of the head is the first division of the thorax, the prothorax, appearing on the back as a large rectangular shield, and bearing beneath the first pair of legs. Behind this are the other two divisions of the thorax, the mesothorax and the metathorax, each bearing on the upper side a pair of wings, and on the lower side a pair of legs. These divisions of the thorax are hidden from above by the first pair of wings or wing-covers, sometimes called the *tegmina.* These vary greatly in length with different individuals; in some they reach to the tip of the abdomen, while in others they are barely half as long. They differ also in appearance according to the sex of the individual. The wings proper are folded more or less fanlike beneath the tegmina; these also vary in size, but in our common forms they are generally so small and abortive that they are useless for flight.

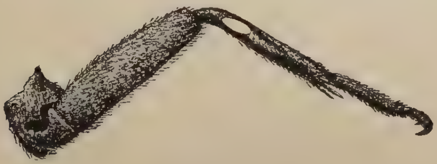
FIG. 16. — Leg of Cricket. Magnified.

The legs of crickets (Fig. 16) are very similar to those of the grasshopper. On the tibia, or second long joint from the body, of the first pair one can easily see with a lens an oval opening covered with a thin whitish membrane; this is supposed to be the organ of hearing and is sometimes called the tympanum. The femur or first long joint of the hind leg is very large, giving space for the muscles by means of which the crickets make their long jumps. All of the feet are tipped with long curved claws arranged in pairs.

The abdomen is rather smooth and is furnished at each side of the hinder end with a rather long, tapering, jointed, antenna-like projection called the stylet. These stylets are round and thickly furnished with short spiny projections and longer, more slender hairs: they probably serve as organs of feeling in the dark places where the crickets spend so much of their time. The most notable feature of the abdomen of the female cricket is the long ovipositor or egg-depositor projecting backward for a distance nearly as long as the body of the cricket. This is easily seen to be composed of two pieces grooved on their inner margins and fitting together in such a way that the grooves form a tube through which the eggs pass. The tip of the ovipositor is a pointed, cone-like process which serves admirably for making holes in the hard ground in which the cricket lays her eggs. The structure of this tip is very suggestive of the pointed cone men use in making driven wells.

The wing-covers of the female crickets consist of a close network of veins connected by a membrane. The venation of the wing-covers of the males (Fig. 17) is very different; the veins are few and far between, with the membrane connecting them thinner and more parchment-like. If the principal vein which extends diagonally across the base of the wing-cover be examined with a microscope, to use the words of Professor J. H. Comstock, "it will be seen to be furnished with ridges like those of a file. On the inner margin of the wing-cover, a short distance toward the base from the end of the principal vein, there

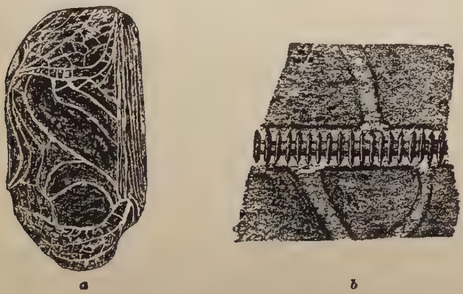

FIG. 17. — *a*, Wing of Cricket; *b*, Ridged Vein. Magnified.

is a hardened portion which may be called the scraper. Each wing-cover is therefore provided with a file and scraper. When the cricket wishes to make his call, he elevates his wing-covers at an angle of about forty-five degrees with the body; then holding them in such a position that the scraper of one rests upon the file of the other, he moves the wing-covers back and forth sidewise so that the file and scraper rasp upon each other. This throws the wing-covers into vibration and produces the call." This process may be easily seen within doors by keeping crickets in glass vessels as directed above.

The eggs of crickets are small, elongate-oval, yellowish objects, and are deposited in masses in the soil about half an inch below the surface. They are laid in autumn and hatch the following spring into little crickets that resemble the adults in general appearance, but have no wings. These grow gradually, shed their skins occasionally, and become mature about midsummer. They feed on grasses, clover, and a great variety of vegetable matter.

Late in summer and early in autumn one can often find the crickets congregated in great numbers along roads and paths running through pastures and meadows. They seek such situations for the purpose of oviposition.

The black crickets are the typical representatives of the family *Gryllidæ*. Our common large species belong to the genus *Gryllus*, the most abundant short-winged form being known as *Gryllus abbreviatus*.

THE EGGS IN THE RASPBERRY CANES

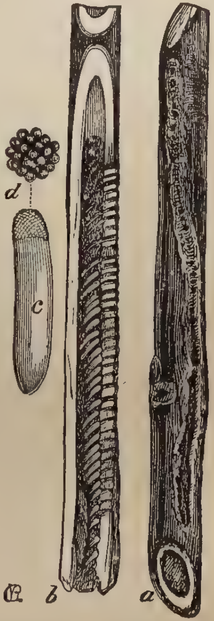

FIG. 18. — Eggs of Tree-cricket. *a*, egg punctures; *b*, cane split open to show eggs; *c*, egg magnified; *d*, egg cap, more magnified. (After Riley.)

BY examining the canes of raspberries during fall or winter one may often find long scars showing punctures that have the appearance of Fig. 18 *a*. If such a cane be split open, there will be found beneath each of the punctures a long, slightly curved, yellow egg, having when magnified the shape represented in *c* of the figure. There frequently will be forty or fifty of these eggs thus standing on end, side by side in the cane.

These are the eggs of the Snowy Tree-cricket, an insect belonging to the same family as our common Black

Cricket, but differing from it greatly in appearance and habits. While the black crickets live upon the ground, the tree-crickets live on shrubs and trees; they also differ in their feeding habits.

Early in summer the eggs in the raspberry canes hatch into young crickets that bear a general resemblance to the full-grown tree-crickets, although of course they are much smaller and have no wings. They feed upon aphides or plant-lice, or other insects, roaming about over branches, twigs, and leaves in search of food. By the latter part of summer they become full-grown: they are then of a pale whitish-green color, about four-fifths of an inch long, and in form resemble Fig. 19. One of the commonest sounds of summer evenings is due to the stridulations of these insects.

Miss Mary E. Murtfeldt has recorded[1] some interesting observations upon a colony of young tree-crickets. "At hatching, each tiny cricket left at the aperture of the bark through which it emerged the filmy pellicle in which it had been enclosed in the egg. There were about a dozen in all, and during the day I kept them under constant observation on my writing-desk. During the day they remained almost motionless in one position, if possible concealed from light and sight on the under side or in the folds of a leaf. They were from the first supplied with berries and various tender leaves, but evidently never touched them for food. On the morning of the fourth day two or three of them were dead and showed signs of having been nibbled by their hungry brothers.

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[1] *Insect Life*, II., 130.

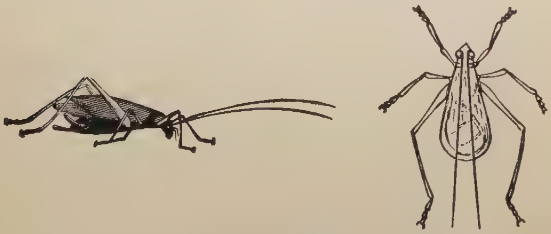

FIG. 19. — Snowy Tree-cricket. (After Riley.)

"Some leaves of plum infested with a delicate species of yellow aphis were then put into the jar, but attracted no immediate attention. As twilight deepened, however, the crickets awakened to greater activity. By holding the jar against the light of the window, or bringing it suddenly into the lamplight, the little nocturnal hunters might be seen hurrying with a furtive darting movement over the leaves and stems, — the head bent down, the antennæ stretched forward, and every sense apparently on the alert.

"Then the aphides provided for their food would be caught up, one after another, and devoured with violent action of the mouth-parts, the antennæ meanwhile playing up and down in evident expression of satisfaction. Unless I had provided very liberally, not an aphis would be found in the jar the next morning, and the sluggish crickets would have every appearance of plethora. Later on in their lives, by reducing them to the point of starvation, I repeatedly made them feed in the daytime, so that I might the more distinctly observe the process, which is certainly very interesting."

The female cricket deposits her eggs in the tender canes of raspberries, blackberries, and grapes; and the twigs of maple, catalpa, willow, and several other trees. The eggs remain in these situations until the following spring.

The Snowy Tree-cricket belongs to the family *Gryllidæ* of the order Orthoptera — the order which includes the grasshoppers, cockroaches, katydids, and similar insects. Scientifically it is called *Œcanthus niveus*.

THE WALKING-STICK

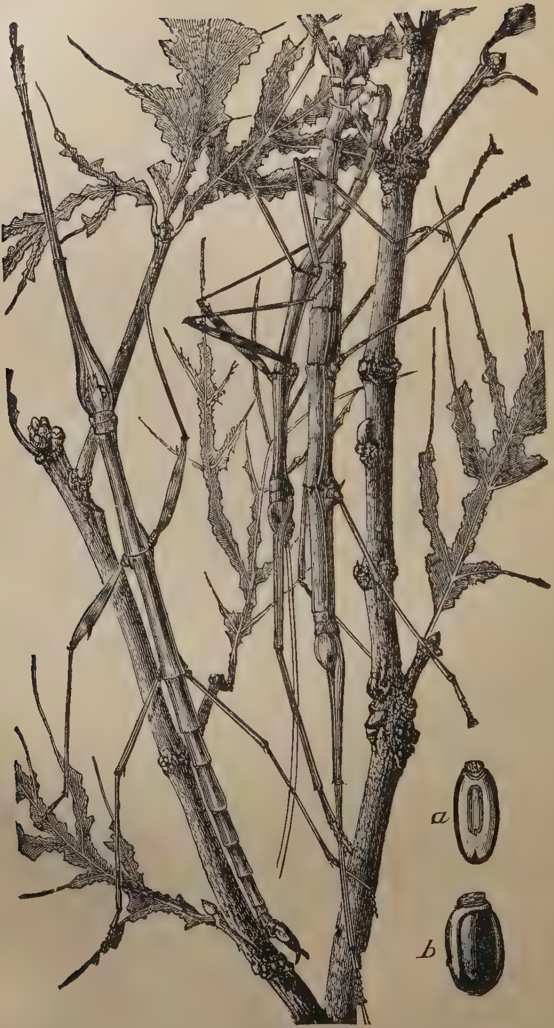

Plate V.—The Walking-stick. (After Riley.)

THE WALKING-STICK

If, during the late summer or early autumn, one beats the limbs of oaks and other trees with a stout stick, holding a sheet or an umbrella beneath, one is likely to find among the various insects that are thus shaken down, an occasional specimen of the curious creatures called Walking-sticks or Stick-insects. They will at once be recognized, even by persons seeing them for the first time, for they are entirely different from other insects, and their common name is suggestive of their form: the body is long, slender, and cylindrical, with the legs and antennæ fitting loosely, reminding one of the twigs on a miniature tree-branch. The general resemblance to a twig is so striking that in their native habitats the insects are very likely to be overlooked unless in motion. The body is two or three inches long, the females being somewhat larger than the males; the antennæ are about two-thirds as long as the body, and the front and hind legs somewhat shorter than the antennæ; the middle legs are shorter than the others. There are no wings.

These walking-sticks feed upon the foliage of various trees, seeming to have a decided preference for the oaks, and when abundant they may do considerable injury. During the autumn months the eggs are dropped, by the fully developed females, loosely upon the ground from the situation in which the insects are feeding.

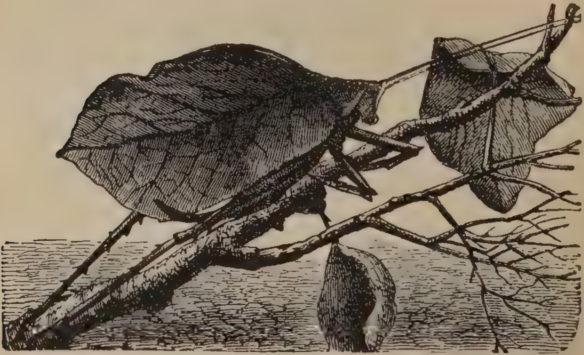

FIG. 20. — A Leaf Insect. (From *Riverside Natural History*.)

The eggs remain upon the ground throughout the winter, being more or less protected by the fallen leaves. Each egg (*a*, *b*) is black except for a whitish stripe upon one side, and has at the upper end a lid-like cover. In spring, when the embryos within have developed into tiny walking-sticks, each lid is pushed open by the young insect, which crawls out and feeds upon the surrounding vegetation. It is green, and in general form resembles the full-grown walking-stick. Content at first to feed upon the leaves of grasses and bushes near the ground, it mounts higher as it increases in size, until, in about six weeks, it becomes full-grown and is found well up in trees. Throughout later life the colors of these walking-sticks vary considerably, different specimens being of many shades of green and gray and brown, the latter predominating in the full-grown insects.

Walking-sticks are found throughout most of the northern states, although, as a rule, they are not very common. In the region named they are the only representative of the peculiar family *Phasmidæ*, to which they belong. This family is included in the order Orthoptera, and is composed of the walking-sticks and the leaf-insects. Many members of it are found in tropical regions, and are among the most perfect examples of mimicry or the resemblance of an animal to its surroundings. By means of these resemblances the insects are enabled to escape the notice of birds and other enemies.

The walking-stick of the United States is called by entomologists *Diapheromera femorata*. In tropical regions there are much larger species.

THE AMERICAN LOCUST OR BIRD GRASSHOPPER

THE AMERICAN LOCUST OR BIRD GRASSHOPPER

One of the most interesting species of grasshoppers is the American Locust or Bird Grasshopper[1] (Fig. 21). This is one of the largest

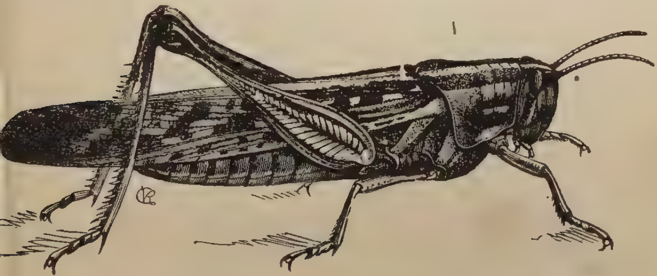

Fig. 21. — American Locust or Bird Grasshopper. (After Riley.)

members of the family, measuring about three inches in length; when flying it might easily be mistaken for a small bird. It occurs abundantly in the southern United States, being found north as far as New Jersey, Ohio, and Illinois. Sometimes it becomes extremely destructive over comparatively small areas. It passes the winter as an adult, thus differing from the great majority of grasshoppers, which hibernate in the egg state.

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[1] *Schistocerca americana.*

The eggs are laid during early summer in the soil, in irregular masses, held together by a cement-like substance. In about a month they hatch into diminutive, wine-red hoppers (Fig. 22 *a*) that feed upon grass or other vegetation; in this first stage there are no indications of wing-pads. After the insect has been feeding for some days it casts its skin, and enters upon the second of its nymph stages. It now resembles Fig. 22 *b*, there being a slight suggestion of wing-pads; the antennæ, which before had but thirteen joints, have become seventeen-jointed, while the color is yellowish-gray mottled with blackish; its length is now 12 mm.,

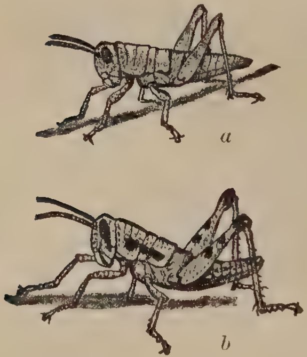

FIG. 22. — American Locust. *a*, first stage; *b*, second stage. (After Howard, Div. Ent., U. S. Dept. Agr.)

the insect having been 10 mm. long before moulting. After the second moult the length increases to 18 mm.; the wing-pads become distinct and point obliquely downward; the antennæ have twenty or more joints; the color varies from a mottled yellowish-gray to a mottled green. With the third moult the insect enters upon the fourth stage of its existence (Fig. 24); the wing-pads are much more conspicuous and point obliquely upward; the joints of the antennæ have increased to twenty-five, and the length of body to 28 mm.; the colors are much the same as before the change of skin. The fourth moult brings the grasshopper to the stage preceding the adult (Fig. 25); it is now a large insect, nearly two

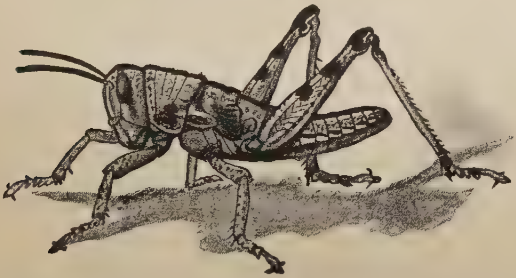

FIG. 23. — American Locust: third stage (twice natural size). (After Howard, Div. Ent., U. S. Dept. Agr.)

inches long (38 mm.), with prominent wing-pads and antennæ of twenty-six joints. When its skin is cast the adult grasshopper appears.

This life history may serve to illustrate the biography of the locust family — the *Acridiidæ* of authors. There are many members of this family, a large number of species — about three hundred — being found in the United States alone. All undergo the *incomplete transformations* thus described in the case of the American Locust, and thus differ decidedly from insects like the butterflies, in which the metamorphoses are complete. To the earlier stages of grasshoppers and similar insects, the name *nymph* is often applied, to distinguish them from the larvæ and pupæ of insects having complete transformations.

The Bird Grasshoppers become full-grown during the latter part of summer. Their habits, when abundant, have been described by Mr. D. W. Coquillet,[1] who writes: "Towards sunset numbers of them may be seen flying into the tops of neighboring trees, sometimes, in the case of a tall oak or hickory tree, alighting in the tops of these from twenty to thirty or more feet from the ground. Here they remain during the night, and early on the following day they again fly to the ground, usually not going any great distance from the trees in which they had passed the night. In the early part of the day they were fond of frequenting bare ground, especially the middle of roads and paths, while if there were any boards lying on the ground in that vicinity, these formed favorite resting-places. Here they could be found congregated in large numbers, lying partially upon one side, apparently enjoying to the utmost the rays of the morning sun. Later in the day they could frequently be found in large numbers upon the droppings of horses in the road, and they appeared to be feeding upon these droppings. Even in the orchards and cornfields, the winged

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[1] *Insect Life*, VII., 226.

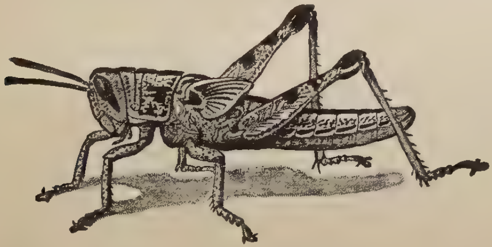


FIG. 24. — American Locust: fourth stage. (After Howard, Div. Ent., U. S. Dept. Agr.)

individuals were frequently found upon the ground, although their favorite situations were on the taller weeds, stalks of corn, or in trees. In the afternoon of August 28, the writer witnessed a partial migration of the winged ones. This began at about one o'clock and lasted until half-past three, there being a slight breeze from the southeast at the time. All of the grasshoppers did not rise on the wing at once, but a few would start up in one place, some in another, and so on, until several thousand would be on the wing at the same time. All of them took a northerly direction, and continued upon the wing until lost to view. The majority flew obliquely upward until attaining a height of

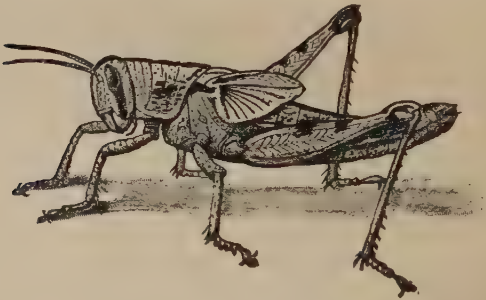


FIG. 25. — American Locust: fifth stage. (After Howard, Div. Ent., U. S. Dept. Agr.)

from fifty to eighty feet from the ground, after which they would continue at about this height until lost to view. The migration was not continuous, there being intervals of from ten to twenty minutes, during which time scarcely a grasshopper would be seen on the wing. They would then start up again, and in a comparatively short time thousands of them could be seen upon the wing in every direction. This migration ceased at about half-past three o'clock in the afternoon. Scarcely a single winged specimen remained where there had been thousands of them before the migration began."

THE MOULTING OF A GRASSHOPPER

THE MOULTING OF A GRASSHOPPER

THE process of shedding the skin or moulting is so universal among insects that a clear understanding of it is desirable on the part of every student of insect life. On this account, I quote at length the admirable description of the last moult of the Rocky Mountain Locust, published many years ago by Dr. C. V. Riley, in one of his classic *Reports upon the Insects of Missouri.* He calls the last nymph stage of this grasshopper the pupa: —

"When about to acquire wings the pupa crawls up some post, weed, grass-stalk, or other object, and clutches such object securely with the hind feet, which are drawn up under the body. In doing so the favorite position is with the head downward, though this is by no means essential. Remaining motionless in this position for several hours, with antennæ drawn over the face, and the whole aspect betokening helplessness, the thorax, especially between the wing-pads, is noticed to swell. Presently the skin along this swollen portion splits right along the middle of the head and thorax, starting by a transverse, curved suture between the eyes, and ending at the base of the abdomen.

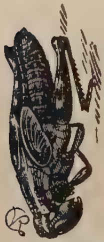


Fig. 26.—Beginning to moult. (After Riley.)

"Let us now imagine that we are watching one from the moment of this splitting. As soon as the skin is split, the soft and white fore-body and head swell, and gradually extends more and more by a series of muscular contortions; the new head slowly emerges from the old skin, which, with its empty eyes, is worked back beneath, and the new feelers and legs are being drawn from their casings, and the future wings from their sheaths. At the end of six or seven minutes our locust—no longer pupa, and not yet imago—looks as in Fig. 27, the four front pupa legs being generally detached, and the insect hanging by the hooks of the hind feet, which were anchored while yet it had that com-

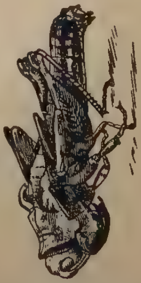


Fig. 27.—Imago protruding. (After Riley.)

mand over them which it has now lost. The receding skin is transparent and loosened, especially from the extremities. In six or seven minutes more of arduous labor — of swelling and contracting — with an occasional brief respite, the antennæ and the four legs are freed, and the fulled and crimped wings extricated. The soft front legs rapidly stiffen, and, holding to its supports as well as may be with these, the nascent locust employs whatever muscular force it is capable of to draw out the end of the abdomen and its long hind legs. This in a few more minutes is finally done, and with gait unsteady as that of a new-dropped colt, it turns round and clambers up the side of the shrunken, cast-off skin, and there rests while the wings expand, and every part of the body hardens and gains strength — the crooked limbs straightening and the wings unfolding and expanding like the petals of some pale flower. The front wings are at first rolled longitudinally to a point, and as they expand and unroll, the hind wings, which are tucked and gathered along the veins, at first curl over them. In ten or fifteen minutes from the time of extrication these wings are fully expanded and hang down like dampened rags.

From this point on the broad hind wings begin to fold up like fans beneath the narrower front ones, and in another ten minutes they have assumed the normal attitude of rest. Meanwhile the pale colors, which always belong to the insect while moulting, have been gradually giving way to the natural tints, and at this stage our new-fledged locust presents an aspect fresh and bright.

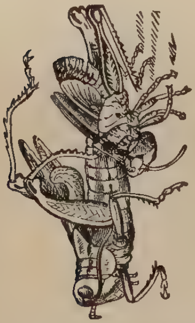


FIG. 28. — Moulting nearly finished. (After Riley.)

"If we now examine the cast-off skin, we shall find every part entire with the exception of the rupture which originally took place on the back; and it would puzzle one who had not witnessed the operation to divine how the now stiff shanks of the mature insect had been extricated from the bent skeleton left behind. They were in fact drawn over the bent knee-joint, so that during the process they were doubled throughout their length. They were as supple at the time as an oil-soaked string, and for some time after extrication they show the effects of this severe bending by their curved appearance.

"The moulting, from the bursting of the pupal skin to the full adjustment of the wings and straightening of the legs of the perfect insect, occupies less than three-quarters of an hour, and sometimes but half an hour. It takes place most frequently during the warmer part of the morning, and within an hour after the wings are once in position the parts have become sufficiently dry and stiffened to enable the insect to move about with ease; and in another hour, with appetite sharpened by long fast, it joins its voracious comrades and tries its new jaws. The moulting period, especially the last, is a very critical one, and during the helplessness that belongs to it the unfortunate locust falls a prey to many enemies which otherwise would not molest it, and not infrequently to the voracity of the more active individuals of its own species."

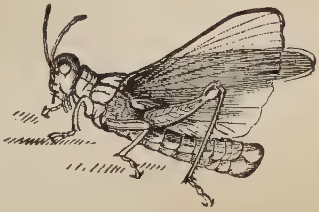


Fig. 29. — Rocky Mountain Locust. (After Riley.)

THE ARMY-WORM

THE ARMY-WORM

There are certain species of insects which are justly regarded with fear in regions subject to their devastations. The Chinch-bug and the Hessian Fly, the Rocky Mountain Locust and the Army-worm, are probably the most notable examples of such pests. And the last named — the Army-worm — probably occurs in destructive numbers over a greater area than the others, with the possible exception of the Hessian Fly.

The Army-worm is no new enemy to American crops. Even in New England, where its outbreaks have been comparatively rare, it apparently occurred in 1743, a year when, according to early records, there appeared millions of devouring worms in armies, threatening to cut off every green thing! That the pest was present in New Hampshire in 1770 is shown by the following paragraph from the Rev. Grant Powers' *Historical Sketch of the Coos Country*, published at Haverhill, N.H., in 1841: —

"In the summer of 1770 this whole section was visited by an extraordinary calamity, such a one as the country never experienced before or since. It was an army of worms which extended from Lancaster, N.H., to Northfield in Massachusetts. They began to appear the latter part of July, 1770, and continued their ravages until September. The inhabitants denominated them the 'Northern Army,' as they seemed to advance from the north or northwest and to pass east and south. They were altogether too innumerable to be counted. Dr. Bouton of Thetford, Vt., told me that he had seen whole pastures so covered that he could not put down his finger on a single spot without placing it upon a worm. He said he had seen more than ten bushels in a heap. They were unlike anything which the present generation have ever seen! There was a stripe upon the back like black velvet, on either side a stripe from end to end, and the rest of the body was brown. . . . They appeared to be in great haste, except when they halted to devour their food. They filled the houses of the inhabitants and entered their kneading-troughs, as did the frogs in Egypt. They would go up the side of a house and over it in such a compact column that nothing of the boards or shingles could be seen. They did not take hold of the pumpkin vine, pease, potatoes, or flax; but wheat and corn disappeared before them as if by magic. They would climb up stalks of wheat, eat off the stalk just below the head, and almost as soon as the head had fallen upon the ground it was devoured."

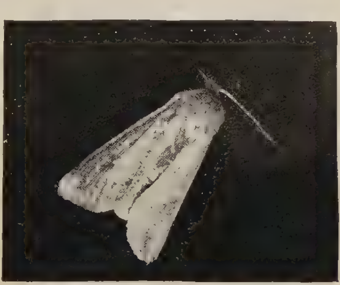


FIG. 30.—Moth of Army-worm.

There is little evidence of the Army-worm again occurring in great abundance in New England until 1861, when it was very destructive, as it was also in 1875, 1880, and 1896.

The story of the life of the individual Army-worm may be briefly told. On some summer night there appears in the meadow a good-sized light brown moth. Flying about, she finds a cluster of strong-growing grass. Into the folded leaves of one or more of these she pushes a number of small whitish eggs, gluing them in rows of a dozen or more. A week or ten days later each egg hatches into a minute, whitish worm, that nibbles at the grass-blades at night, and in the daytime hides beneath the grass from the rays of the sweltering sun.

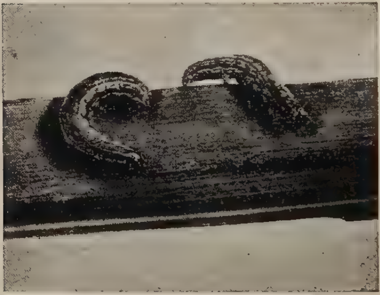


FIG. 31.—Army-worms; natural size. (From New York Experiment Station.)

It grows rapidly in size. At the end of a week it moults, or casts its skin, a process in which the old skin splits open along the back and the worm crawls out, clothed in a new skin that had developed beneath the old one. Again it feeds as before, its voracity increasing with its size. This moulting is repeated four or five times during the month after the worms hatch, so that by the end of this period the insect is an inch and a half long, and has the familiar markings of the full-grown Army-worm.

The instinct of the worm now teaches it to seek more secure shelter for the helpless stage upon which it is about to enter. It burrows into the soil an inch or less and wriggles about in the earth until it produces a hollow cell. In this it casts its skin again and becomes a pupa — the third stage of its existence. When the worms are very abundant, many of them do not go into the ground, but change to pupæ beneath whatever shelter may be at hand. About a fortnight later, another change takes place, and the fully developed moth emerges from the pupa, thus completing the round of the insect's life. The moths fly towards dusk and at night, and by means of their long tongues, coiled up when not in use, they suck the nectar of various flowers.

The moths seem attracted by buildings. I have been told of their swarming in great numbers, toward the close of cloudy afternoons, about barns and outbuildings, and have known them to be trapped by thousands in the projecting *porte cochêre* of the main building of the New Hampshire College.

During ordinary years army-worms are present in most of the regions where the outbreaks occur, individual worms feeding here and there in meadow and pasture lands, but the number is not sufficient to attract notice. At such times their habits of life are very similar to those of the common cutworms, to which, indeed, the army-worms are closely related. It is only when these insects become so excessively numerous that they exhaust the food supply of the field in which they develop, that that "army" habit is assumed. Then, however, they are forced to seek new quarters for food, and as their only mode of progress is by crawling along the ground, they move in solid masses toward adjacent fields. "Their numbers at these times,"

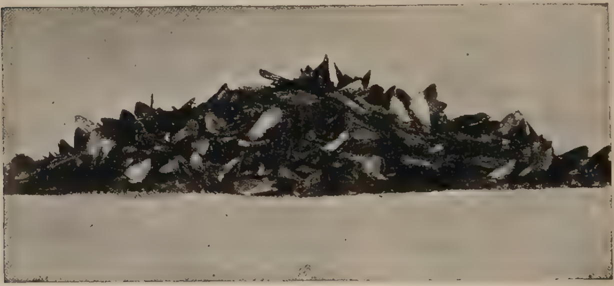


FIG. 32. — A Thousand Army-worm Moths.

wrote Dr. C. V. Riley, "are often so enormous, and their voracity so great, that it is impossible for one who has not been an eye-witness to appreciate it fully. . . . The Army-worm when travelling will scarcely turn aside for anything but water, and even shallow watercourses will not always check its progress, for the advance columns will often continue to rush headlong into the water until they have sufficiently choked it up with their dead and dying bodies to enable the rear guard to cross safely over. I have noticed that after crossing a bare field or bare road where they are subjected to the sun's rays, they would congregate in immense numbers under the first shade they reached. In one instance I recollect their collecting and covering the ground five or six deep all along the shady side of a fence for about a mile, while scarcely one was seen to cross on the sunny side of the same fence." This avoidance of the sunshine must have been noticed by every observer of Army-worm outbreaks. On damp, cloudy days

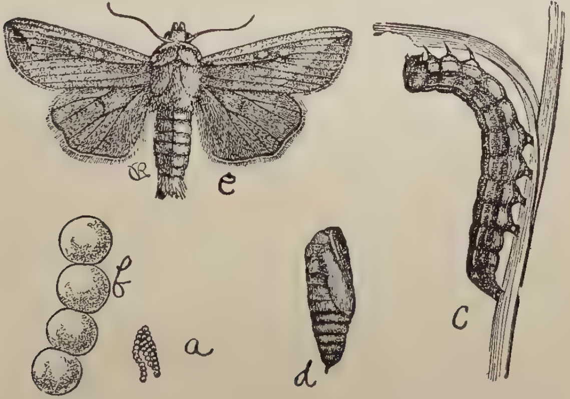


FIG. 33. — The Army-worm: *a*, egg-mass, natural size; *b*, eggs, magnified; *c*, full-grown larva; *d*, pupa; *e*, moth. (After Riley.)

one may find numbers of them feeding near the top of grass and grain stalks, but on hot, sunny days few if any are to be found in such situations. They then occur in the shaded rubbish at the soil surface.

The Army-worm feeds by preference upon plants of the great grass family, which includes both the grasses and grains. The moths are especially attracted, for the deposit of their eggs, to rank growths of grass-like plants. To this is due the fact that in New Hampshire in 1896 the brood of worms destructive in July was oftenest found in barley fields, while that destructive in September ravaged the fields of Hungarian grass. In feeding upon timothy and similar grasses the leaves are first stripped, and in cases of severe attacks the heads will be wholly or partially gnawed off; one such is represented in Fig. 34. They also feed freely upon the leaves and more or less upon the succulent stalks of wheat, oats, barley, rye, sorghum, and Indian corn. Generally they feed upon clover only when driven to it by hunger.

Fortunately for the American farmer, the Army-worm has a host of natural enemies, which generally keep it below the danger line. A large number of birds consider the juicy worms excellent eating, and feed freely upon them. A list of such birds would include nearly all our native insectivorous species that search for food upon the ground, but special mention should be made of the robin, the blackbird, the bobolink, and the meadow lark, which search grass lands for insect larvæ more persistently than many other of our common birds. These and other birds are very useful in keeping army-worms and cutworms in check, and should be encouraged by every one.

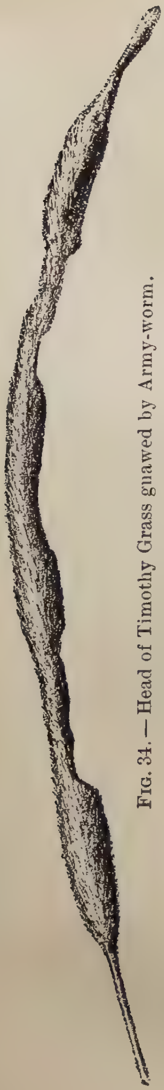


FIG. 34. — Head of Timothy Grass gnawed by Army-worm.

But the birds are not the only enemies of the Army-worm. In the fields where the pest has been present, in 1896, there have also been found a great many large black beetles, some of them similar to the one represented in Fig. 35, and others somewhat larger. During July I examined a barley field in which the grain had recently been cut and placed in piles, beneath which the army-worms had congregated in great numbers. There were also present beneath each pile about a dozen of these black beetles, devouring the helpless worms. These predaceous beetles are commonly called ground-beetles, because of their habit of living upon the ground, but sometimes they are also called caterpillar-hunters. There are also many species of internal parasites that prey upon the army-worms. Among the most abundant of these are certain two-winged flies that glue eggs upon the backs of the worms. The eggs hatch into tiny footless maggots, that enter the bodies of the worms when they hatch, and develop inside at the expense of their unwilling hosts. Finally they kill the worms, and the maggots change to pupæ, from which they soon emerge as flies. These are called Tachina flies.

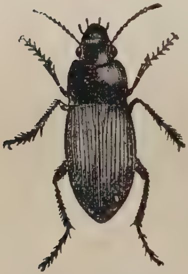


Fig. 35. – Ground-beetle. (After Riley.)

There are several species of four-winged ichneumon-flies that have a similar history, and are often very destructive to the hosts of army-worms.

The larger ground-spiders also feed freely upon these worms; and the moths are often entrapped in the webs of the spinning spiders (Fig. 36).

More fateful and insidious even than these other enemies, are the microscopic germs of a bacterial disease — a sort of insect cholera — that often attacks the Army-worm when it becomes over-abundant, reducing quickly its invading ranks to below the normal level.

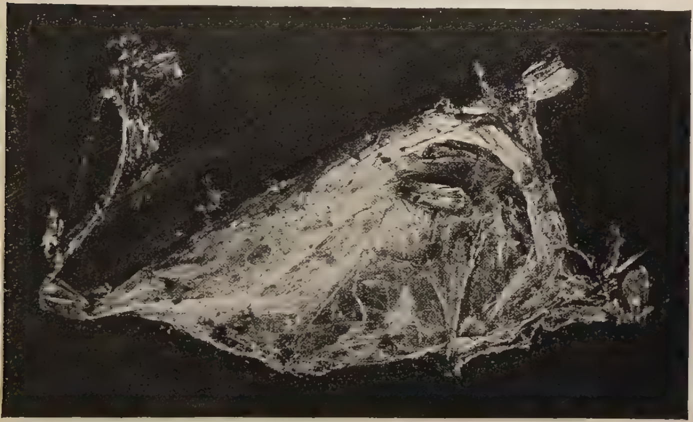
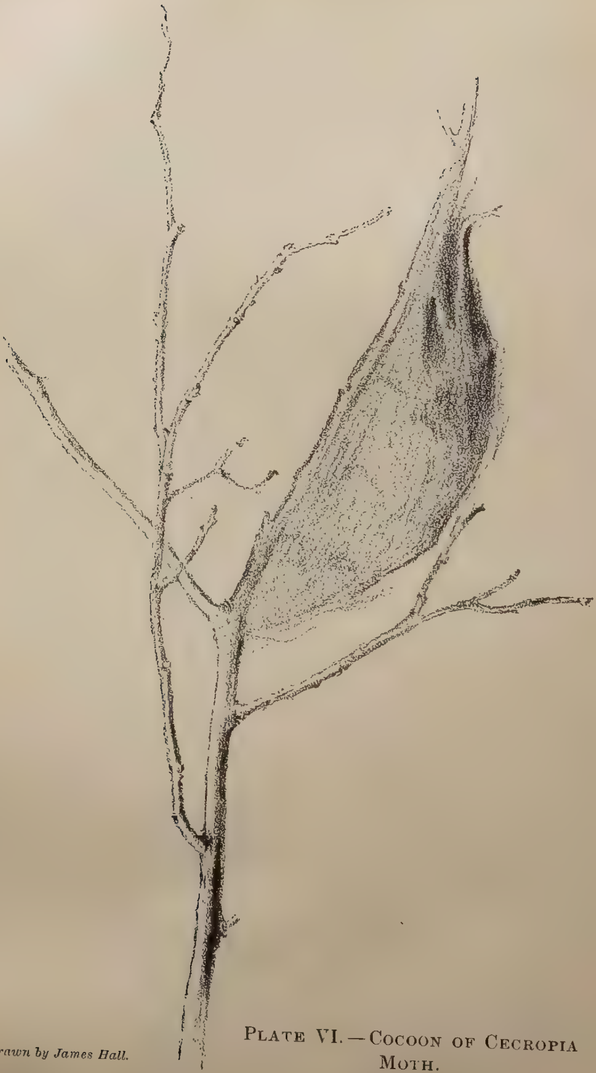


FIG. 36. — Army-worm Moths entrapped in a Spider's Web.

To the action of these various natural checks is doubtless due the seemingly strange appearance and disappearance of this vexatious pest.

Nature strives ever to keep a balance in her affairs, and when an insect becomes too abundant, she marshals her various forces to bring it into subjection.

THE CECROPIA EMPEROR MOTH



Drawn by James Hall.

PLATE VI. — COCOON OF CECROPIA MOTH.

THE CECROPIA EMPEROR MOTH

AFTER the leaves have fallen in autumn, one often finds on the twigs of various fruit and shade trees large, grayish-brown cocoons, having the general appearance of Plate VI. These contain the pupæ or chrysalids of the beautiful Cecropia Emperor Moth[1] — one of the largest and

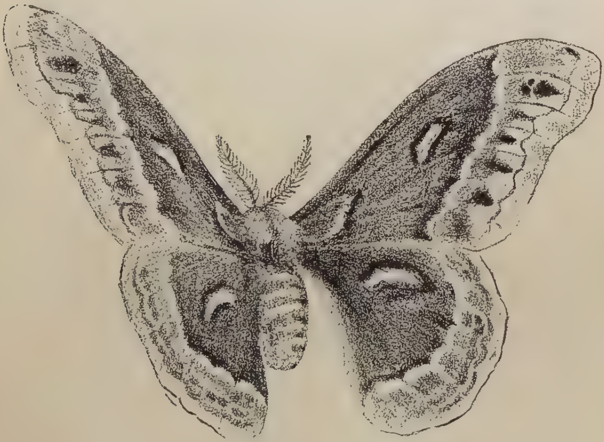


FIG. 37.—The Cecropia Emperor Moth.

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[1] *Attacus cecropia.*

handsomest American insects. It often measures six or seven inches across the expanded front wings. In color the wings are a grizzled, dusky brown, with the hind margins of a clay color. In the central area of each wing there is an opaque, crescent-shaped, dull-red spot with a white centre and a narrow black edging. A little more than half way from the body to the outer margin of each wing there is a wavy, reddish band, bordered internally with white; next to the shoulders, the front wings are dull red, with a curved, whitish band; near the tip of each of these wings there is an eye-like black spot within a bluish-white crescent. The upper sides of the body and legs are reddish; the front of the thorax and the hind margins of the rings of the abdomen are white; the under surface of the body is checkered with red and white.

Early in summer these moths emerge from the cocoons. They soon deposit their eggs upon apple, pear, cherry, maple, and other fruit and shade trees. The eggs hatch a week or two later into small, spiny caterpillars that feed upon the succulent leaves, and increase rapidly in size. They moult occasionally, and become full-grown late in summer. They are then about three inches long, nearly an inch in diameter, and have rows of yellow or coral-red tubercles along the back and sides. Their next duty is to spin the large cocoons of loose silk within which they transform to brown pupæ. They pass the winter in this condition, and early the following summer develop into moths.

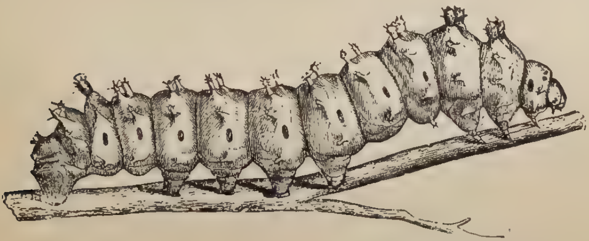


FIG. 38. — Larva of Cecropia Moth. (After Riley.)

Cecropia caterpillars sometimes do serious damage to the tree plantations of the prairie states; and occasionally defoliate shade trees in the east. They are known to feed upon at least fifty varieties of trees and shrubs. Fortunately they are subject to attack by many parasitic enemies, which serve greatly to check their increase, while certain woodpeckers are known to tear open the cocoons in winter and feed upon the pupæ.

The Cecropia Moth belongs to the family of giant silk-moths called by entomologists *Saturniidæ.* This family includes such magnificent insects as our Luna and Polyphemus Moths and the gigantic Atlas Moth of India. They are generally large-bodied insects, with immense wings; the males have feather-like or pectinate antennæ.

THE APPLE-LEAF CRUMPLER

THE APPLE-LEAF CRUMPLER

Over a large portion of the United States one can often find, during the winter months, apple and other fruit trees that have upon their branches masses of dry and withered leaves, held together more or less loosely by silken threads, somewhat as represented in Fig. 39 *b*. If one of these masses be pulled apart, there may be found inside a long, horn-like case (*a*) which, if carefully cut open, will be seen to contain a brownish worm or caterpillar, about half an inch long. This is the insect commonly called the Leaf-crumpler; its presence in the mass of crumpled leaves may be explained in this way: During the early summer there appeared in the orchard numbers of small, grayish moths (*d*) which deposited eggs probably upon the leaves of the apple trees. These eggs soon hatched into tiny brown worms or caterpillars that fed upon the leaves, and by means of silk spun from their mouths they constructed tubular cases, inside of which they remained concealed. When eating they pushed their heads and front legs out of the open end of the tube and drew the leaves up to them so they could feed upon them readily. They increased gradually in size, moulting or shedding their skins occasionally, and added more and more partially eaten leaves to the mass around their tubes, so that by the end of summer there was quite a bunch of withered leaves surrounding each case.

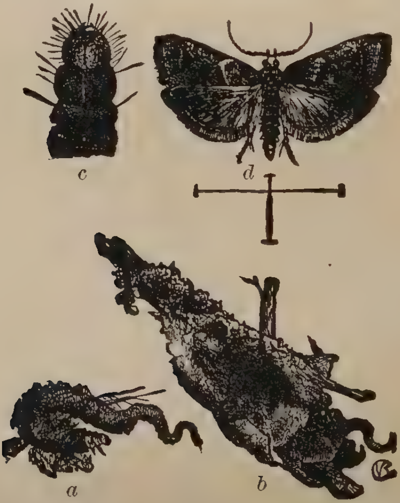


FIG. 39.—Leaf-crumpler: *a*, larval case; *b*, larval case with dead leaves; *c*, front part of larva; *d*, moth, magnified. (After Riley.)

In autumn the leaf-crumpler caterpillars seem to know that unless they fasten their cases securely to the twigs, the cases will fall to the ground to be blown hither and thither by the wintry winds. At any rate, they have the good sense to guard against such an unhappy fate by attaching them to the twigs by means of silken threads, frequently taking the additional precaution of gnawing away the tender bark to insure a firm hold. Having thus anchored its abiding-place, the caterpillar retreats inside its tube and settles down to pass the long winter. With the first cold weather its senses doubtless are benumbed, and it practically goes to sleep for the rest of the time. It is one of the most curious things in nature that these caterpillars can endure very low temperatures without injury to their seemingly delicate bodies. Thus they remain until the warm rays of the spring sun bring them back to life. The fact that the subtile alchemy of life has been keeping the fires of existence burning through the winter is shown by the emaciated condition of the caterpillar; it is very much smaller and more shrunken than it was when it went into winter quarters. The same welcome sunshine that brings the caterpillar out of its lethargic sleep starts the tiny leaves of the surrounding buds, so that when the hungry insect finally peeps forth, it sees an abundant supply of food all around.

His crumplership soon proceeds to break his fast with a good will, often to the injury of the tree upon which he lives. Sometimes both flower-buds and leaf-buds are devoured. The caterpillars continue feeding and growing until late in the spring or early in summer. Then they change to pupæ, still within their cases, and a fortnight later emerge as moths, thus completing the yearly cycle.

Comparatively few larvæ of butterflies or moths live as long in the larval state as do these leaf-crumplers. A large proportion of such insects hibernate in the pupa state, though many pass the winter in the condition of the egg, and some hibernate as adults.

The Leaf-crumpler sometimes does serious damage to young orchard trees, especially in spring, when it attacks the buds. But it is a simple matter to pick off and destroy the cases and thus prevent the injury to the trees. Its food plants include the apple, quince, and probably the peach, as well as both the wild and cultivated varieties of cherry, plum, and crab-apple. The insect is known to entomologists as *Phycis indigenella;* it belongs to the family *Pyralidæ* — or snout-moths — of the order Lepidoptera.

THE APPLE-LEAF SKELETONIZER

THE APPLE-LEAF SKELETONIZER

In many of the middle and western states, especially in the Mississippi Valley, the leaves of young apple trees frequently have the green upper surface eaten off by a small brownish worm, called the Leaf-skeletonizer, because it leaves the veiny skeleton of the leaf uneaten. In nurseries and young orchards this insect often does considerable damage to the young trees.

The life history of this insect may be briefly summarized as follows: The minute purplish-gray moths, whose wings when spread out measure scarcely half an inch from tip to tip, lay their eggs probably upon the leaves and tender twigs of the apple late in spring or early in summer.

Each of these eggs soon hatches into a small worm that begins feeding upon the green substance of the upper surface of the leaf. It increases slowly in size, moulting occasionally, and as it grows older spins, by means of silken glands opening from the mouth, a protective silken web over the leaf surface. It continues to feed beneath this web until five or six weeks after emerging from the egg, when it becomes full-grown as a larva. It is now half an inch long, with four shining black, wart-like projections on the back just behind the head, while the color varies in different specimens, from an olive or pale green to a dull brown.

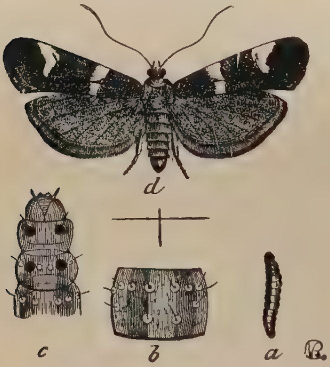


FIG. 40.—Leaf-skeletonizer: *a*, larva; *b*, part of back, magnified to show markings; *c*, head and front part of larva, magnified; *d*, moth, magnified. (After Riley.)

The fully developed larva spins a silken cocoon, generally on the leaf beneath its web. In this cocoon it changes to the pupa or chrysalis state, and about two weeks later it emerges as a moth, thus completing the life-cycle of the first brood of the season. The moths of this brood lay eggs for a second generation of the caterpillars, which form cocoons before winter sets in, and hibernate in the pupa state. The moths from the pupæ emerge the following spring. But this insect is very irregular in its development, as one can easily find all sizes of the larvæ at almost any time during the season.

This leaf-skeletonizer belongs to the family *Phycitidæ*, of the order Lepidoptera. It is called by entomologists *Canarsia hammondi.*

THE OAK-LEAF MINER

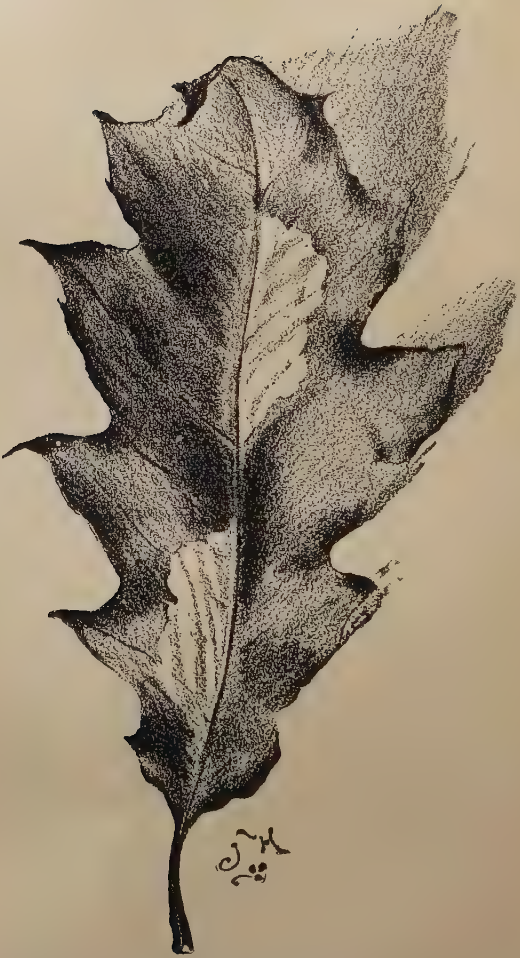


Plate VII.—Oak Leaf, showing White Blotch Mines.

THE OAK-LEAF MINER

Many of the oak leaves which hang on the trees through the winter are found to have discolored spots upon the upper surface. If such a spot be touched with a pin or the point of a knife, it will be seen that the upper epidermis or skin of the leaf is there separated from the under portion, so that it may readily be peeled off in a little flap. When this is done, one is likely to find in the inner part of the leaf thus revealed a tiny worm or larva, about one-sixth of an inch long. This is a leaf-miner, which has been feeding upon the tissues of the leaf, literally illustrating Lowell's lines: —

> "And there's never a leaf nor a blade too mean
> To be some happy creature's palace."

The life history of this miner of oak leaves may be briefly summarized in this way: A tiny moth, — so small as to be almost microscopic, — with delicate fringes on its wings (41 *d*), deposited upon the upper surface of the leaf an extremely minute egg, which in a few days hatched into a little caterpillar, that burrowed through the thin tissue of the leaf surface, and at once began feeding upon the green cells beneath. As it fed, it formed a hollow cavity in which it could turn around; this cavity was constantly enlarged by the growing caterpillar, which ate along the different edges, forming a blotch mine, rather than a long and narrow one. Every few days the larva cast its skin, or moulted, increasing slightly in size each time. After two weeks of such growth, it had moulted five or six times, and was a flattened caterpillar (*a*) about one-fifth of an inch long, having a row of shiny plates along the back, practically no feet, and a pair of peculiar jaws well adapted to eating the

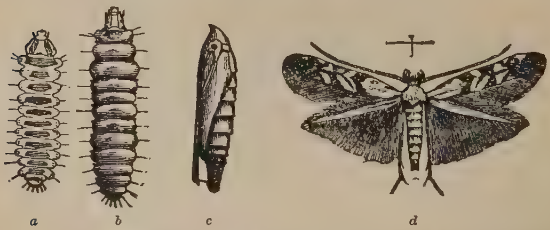


FIG. 41.—Oak-leaf Miner: *a*, *b*, larva; *c*, pupa; *d*, moth. Magnified. (After Comstock.)

inner tissues of the leaf. These larvæ soon moult again, and assume a distinctly different form; they become cylindrical instead of flat, have fairly well-developed feet, and more distinct eyes than they had before. This is the last larval stage; the mine has now become as large as it will be made; it occupies about half a square inch, and, as seen from above, is generally of a whitish or brownish-white color.

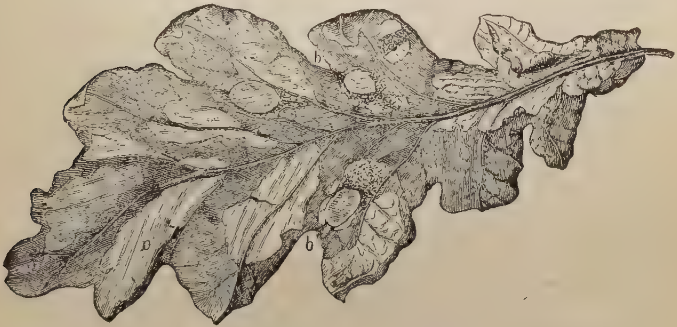


FIG. 42.—Oak Leaf, showing Mines: *b*, *b*, cocoons. (After Comstock.)

The cylindrical larva spins, by means of glands in its mouth, a thin silken covering over one part of the bottom of the mine, thus forming a sort of cocoon, beneath which it soon changes to the light brown pupa or chrysalis, that bears on its front end a pointed projection, having a ragged edge. By means of this, a week or so later, when the insect is again ready to change, — this time to the adult moth, — the pupa works itself part way out of the cocoon and mine, and, breaking open along the front end, discloses the moth, which emerges.

These leaf-miners pass the winter within the leaves in the last, cylindrical, larval stage, pupating early in spring. There are several broods during the summer.

This species belongs to the family *Tineidæ*, of the order Lepidoptera, and has a scientific name much longer than so tiny a creature deserves, being called *Lithocolletis hamadryadella.* There are other species of leaf-miners, also found in oak leaves, whose life histories are quite similar to this one.

THE APPLE-LEAF TENT-MINER

THE APPLE-LEAF TENT-MINER

ONE can very commonly find, in autumn and winter, on the under side of apple leaves, a tent-shaped mine (Fig. 43), inhabited by a small, grayish, slightly hairy worm. This is the insect named above; it hatched from an egg deposited on the apple leaf during the summer by a small, dark moth, of a steel-gray or brownish color. The young larvæ feed upon the inner tissues of

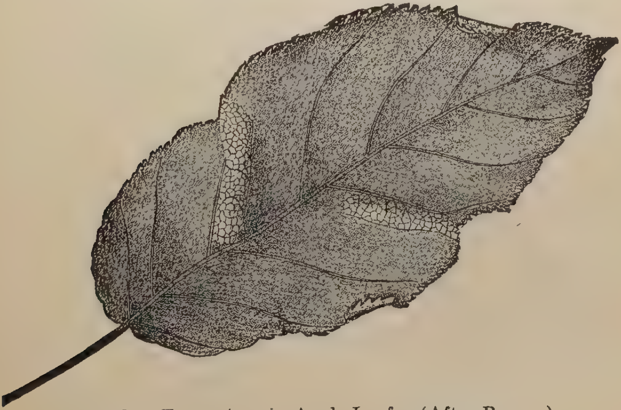


FIG. 43.—Tent-mines in Apple Leaf. (After Brunn.)

the leaf, bending one side so as to produce a tent-shaped mine, in which, when full-grown, it changes to the pupa or chrysalis state. The pupa is a slender, brownish object found in the mine from which in due time the moths emerge. The moth is extremely small and delicate, yet under the microscope it shows the most marvellous perfection in the details of every part of its structure.

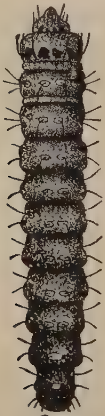


FIG. 44.—Larva. Magnified. (After Brunn.)

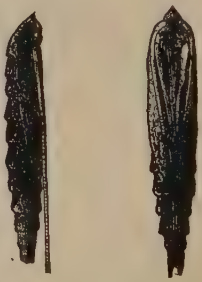


FIG. 45.—Pupa. Magnified. (After Brunn.)

In the mine of this larva there is frequently found a pretty, white, banded, silken cocoon instead of the larval miner or its pupa. This is the cocoon of a parasite belonging to the interesting family of Microgasters. The cocoon is of an oblong, cylindrical shape, one-eighth of an inch long and one-third as wide as long; there is a darker appearing band around the middle. The darker appearance is caused not by any difference in the color of the silk, but because the cocoon is there very much thinner than at the ends. To each end there is attached a cord of fine silken threads, which are also fastened to the sides of the leaf-mine, thus suspending the cocoon after the manner of a hammock. If the mines containing these cocoons are kept in a glass bottle, or under a tumbler, there will develop from each a small black fly — the adult parasite, one of the Microgasters, technically

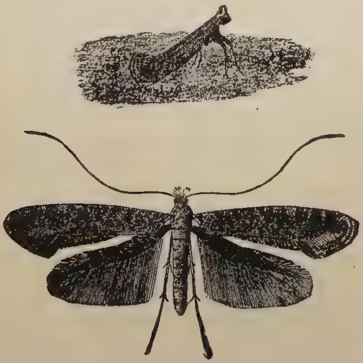


FIG. 46. — Moth. Magnified. (After Brunn.)

known as *Apanteles ornigis.* It is of special interest because its cocoon is so different from that of the other members of the family.

This tent-miner passes the winter in the larva state, pupating in spring. Like the other leaf-miners, it belongs to the family *Tineidæ*, and is called in the books *Ornix geminatella.* It occurs over a wide range of territory, apparently being found throughout most of the United States.

THE APPLE-LEAF TRUMPET-MINER

THE APPLE-LEAF TRUMPET-MINER

THROUGHOUT many of the eastern and central states the observant naturalist often sees leaves of apple trees having brown trumpet-shaped mines showing distinctly upon the upper surface, within which will be found a small, green, footless larva having a brown or blackish head. This insect is called the Apple-leaf Trumpet-miner or sometimes the Apple-leaf Tischeria.

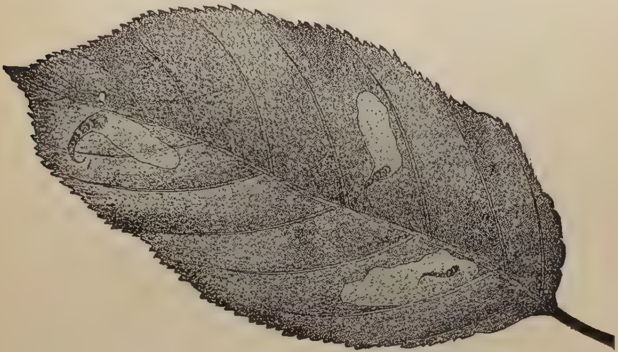


FIG. 47. — Apple Leaf, showing Trumpet Mines. Magnified. (After Brunn.)

Sometime during the summer a tiny dark

brown moth laid upon the apple leaf a still more tiny egg. In a few days the egg hatched into a little larva that burrowed through the outer skin of the leaf into the succulent tissue beneath. It fed upon this green tissue, eating more and more from day to day: thus it gradually worked ahead, leaving behind it a track where it had fed — a track which gradually widens as the insect progresses until it becomes broad and trumpet-shaped. "The color of the mine on the upper surface," writes Mr. A. E. Brunn, "is usually some shade of brown, although I have sometimes observed it to be dirty white. From the under surface of the leaf the mine would hardly be observed unless held up towards the light or examined closely, when the mined portion of the leaf would be seen to be of a lighter shade of green than the rest. The linear portion of the mine on the upper surface is crossed by crescent-shaped patches of white, which in many cases are continued a short distance into the body of the mine. Often the miner after commencing the body of the mine will turn and eat around the

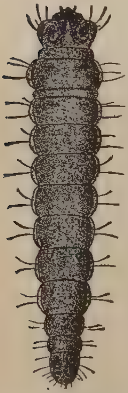


FIG. 48. — Larva. Magnified. (After Brunn.)

linear portion, obliterating that part and causing the mine to appear like a blotch mine. In such cases the white crescent-shaped patches will be found somewhere in the body of the mine indicating the position of the linear portion. These white markings are, however, wanting in some instances; but as the color of the linear portion of the mine is a little darker brown than the rest, we can still tell where the mine commenced. The position of the mine on the leaf is variable; it may be along the edge of the leaf, causing it to curl over at that point, or along the mid-rib, or else between these points. As the leaf dries, the mine assumes a tentiform shape." The larva grows slowly and casts its skin occasionally. "The upper and lower surface of the mine is densely lined with silvery white silk. The excrement is deposited without the mine through one or more openings which are situated at one end and on the lower surface of the mine. Within these clean and comfortable quarters the larva passes the winter." Early in spring it changes to a pupa within the mine, making no

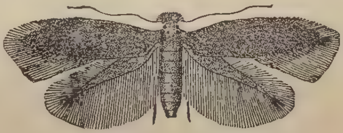


FIG. 49.—Moth of Trumpet-miner. Magnified. (After Brunn.)

cocoon. A fortnight or so later the pupa pushes part way through the upper surface of the mine, and the moth emerges from it.

These mines and the larvæ within them may be found throughout the fall and winter, and are interesting objects for study. Sometimes, instead of the flat green larva, there will be found in the mine one or more tiny pupæ of a four-winged parasitic fly, which has killed and eaten the miner and appropriated its quarters.

The Apple-leaf Trumpet-miner is technically called *Tischeria malifoliella.* It belongs to the family *Tineidæ.*

THE MILKWEED CATERPILLAR OR MONARCH BUTTERFLY

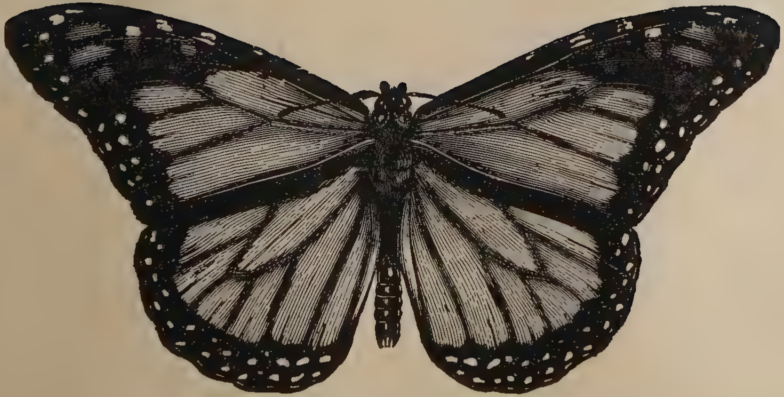


Plate VIII.—The Monarch Butterfly. (After Riley.)

THE MILKWEED CATERPILLAR OR MONARCH BUTTERFLY

The life history and habits of this insect are of peculiar interest. The female butterfly deposits her eggs singly on the under side of the milkweed leaves. The egg is conical in shape and pale yellow in color. In a few days there hatches from it an odd-looking little caterpillar, about one-tenth of an inch long, pale green in color of body, but with a jet-black head. It first eats the empty egg-shell, and then nibbles the milkweed leaf. It continues to eat the leaf for

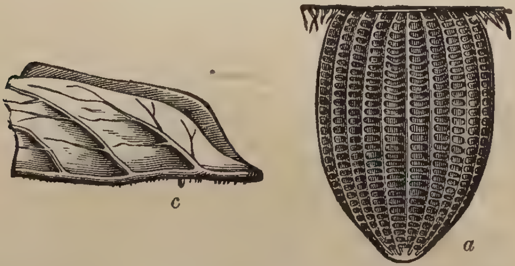


Fig. 50.—Monarch Butterfly Egg: *c*, on leaf, natural size; *a*, magnified. (After Riley.)

about a week, when it becomes restless, spins a thin layer of silk upon the leaf, and prepares to moult or shed its skin. The skin splits open along the back, and the caterpillar crawls out clothed in a new and larger covering. Two little horns on the back at each end of the body now begin to show plainly. As soon as the moulting is well over, the caterpillar again devours the milkweed foliage for some weeks, being interrupted twice again by the process of moulting. It then becomes full-grown, when it appears much like the figure above, with black, white, and yellow as the principal colors. When full-grown, the caterpillar becomes very restless, and generally leaves its host plant for the more secure shelter of a fence or stump. Here, in a more or less concealed situation, it spins a little tuft of silk on some projecting plane, and then entangling its hind legs in the silk, lets go with the other, and hangs downward as shown

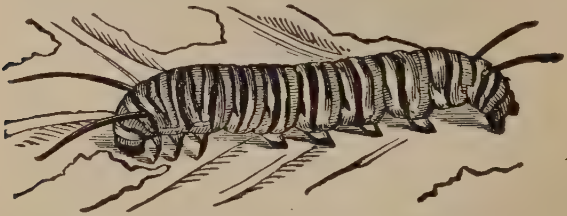


FIG. 51.—The Milkweed Caterpillar. (After Riley.)

at *a* in Fig. 52. In about twenty-four hours the skin splits open along the back and shrinks upward as shown at *b* of the same figure. The animal thus revealed is very different from the caterpillar; it is the newly formed pupa or chrysalis.

There now comes a difficult feat for the insect to perform. It is to get rid of this dried-up, useless skin without becoming disentangled from the silken web. It does it, however, and Dr. C. V. Riley, in one of whose reports the accompanying figures originally appeared, has described the process as follows: "The soft and supple chrysalis yet showing the elongate larval form hangs heavily from the shrunken skin. From this skin it is to be extricated and firmly attached to the silk

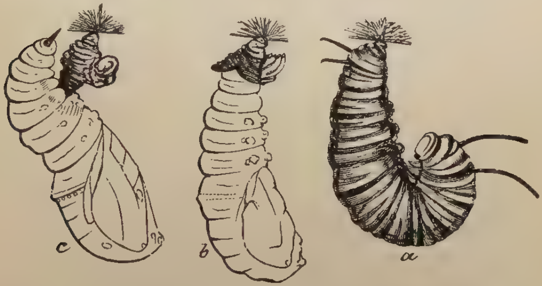


FIG. 52.—The Milkweed Caterpillar changing to a Chrysalis. (After Riley.)

outside. It has neither legs nor arms, and we should suppose that it would inevitably fall while endeavoring to accomplish this object. But the task is performed with the utmost surety, though appearing so perilous to us. The supple and contracted joints of the abdomen are made to subserve the purpose of legs, and by suddenly grasping the shrunken larval skin between the folds of two of these joints as with a pair of pincers, the chrysalis disentangles the tip of its body and hangs for a moment suspended, as shown at *c*. Then, with a few earnest, vigorous jerking movements, it succeeds in sticking the horny point of its tail into the silk, and securely fastening it by means of a rasp of minute claws with which the point is furnished. The moment the point is fastened, the chrysalis commences a series of violent jerkings and whirlings to dislodge the larval skin, after which it rests from its efforts and gradually contracts and hardens until it has the appearance of the accompanying illustration." The chrysalis is, as Dr. Riley has remarked, "a beautiful object, and as it hangs pendent from some old fence or board, it reminds one of some large ear-drop." Within it the butterfly rapidly develops, and in a short time emerges to continue the cycle of insect existence. So it has passed through the four great stages of insect life,—the egg, the larva or caterpillar, the chrysalis or pupa, and the adult or imago.

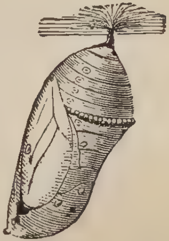


Fig. 53.—Chrysalis of Monarch Butterfly. (After Riley.)

This Monarch Butterfly is found over a large part of the world, and is frequently seen in immense flocks. For a butterfly, it lives a long time in the adult condition. Mr. J. A. Moffatt, a well-known Canadian entomologist, in discussing this butterfly, writes: "I regard it as a particularly interesting creature in every respect; although so common it is never 'vulgar,' never in a hurry; it has the easy grace of the leisurely class. I have thought that one who has seen it only in an open country can form but an inadequate conception of the diversity of its movements on the wing. To see one, on a bright summer day when a stiff breeze is blowing, disport itself about the wide-spreading top of a high tree, is a choice pleasure. It seems fairly to revel with delight in a gale; now it rolls, and tosses, and heaves, always heading against the wind; now it spreads its sails to the breeze and is hurried violently backward and upward; again it furls them, and slowly descending and advancing it describes a variety of the most charmingly graceful curves and waves and undulations imaginable; a thing of beauty to look at, and a joy to think of forever after. Attempts have been made to attach to it common names. I have thought when watching one at such a time that 'the storm king' would be very appropriate and quite befitting its regal character."

Many observers have reported seeing immense flocks of monarch butterflies flying southward in autumn, and it is believed by our most competent entomologists that this insect is really a migrant, following the birds southward in the fall and coming north in the spring. Some years ago Mr. William Edwards observed a swarm of butterflies, believed to be this species, from the top of Pegan Hill in Natick, Mass., which he describes thus: "The day was warm and summer-like, with no wind to disturb the flight of butterflies, which was remarkably steady and even like the flight of migratory birds, and very unlike the usual zigzag movement of butterflies. We watched them for nearly an hour as they appeared in view from the north and moved steadily onward toward the south. Sometimes they appeared singly, sometimes in groups of three or four, but oftener in pairs and flying six or eight feet apart. Being anxious to obtain a specimen, that the species might be determined, we made several vain attempts to bring one down by sending our walking-sticks after them. This put them in great confusion, entirely breaking up their line of march and causing them to dodge rapidly to the right and left and frequently to drop down several feet: although they continued on at the same rate of speed, they seemed unable to gain their former even flight, but kept up this zigzag motion till lost sight of in the distance. They were apparently one of our largest species, and were visible at least one-eighth of a mile as they appeared in sight: it seems an important fact that they did not change their altitude in passing over the hill. We also noticed when descending the hill to the north that they were flying at the same level till we were so far below them that they appeared but mere specks in the air above our heads, and before we had reached the plains below we had entirely lost sight of them. There was no reason to suppose that the butterflies changed their course in order to pass over this hill or that the flight did not extend over the surrounding country." When such swarms of butterflies come to rest, they alight upon trees and bushes, festooning them in great numbers.

Of all the ways in which insects pass the winter this butterfly seems to have chosen the most delightful. It is indeed one of the most fascinating of insects in many respects, well worthy of the following verse addressed to it by Dr. C. V. Riley:—

"Lazily flying
Over the flower-decked prairies, West;
Basking in sunshine till daylight is dying,
And resting at night on Asclepias' breast;
Joyously dancing,
Merrily prancing,
Chasing his lady love high in the air,
Fluttering gaily,
Frolicking daily,
Free from anxiety, sorrow, and care!"

The Monarch or Archippus Butterfly belongs to the family *Nymphalidæ*, of the great order Lepidoptera—the order of scale-winged insects to which the moths and butterflies all belong. Technically it is called *Danais archippus*, or sometimes *Anosia plexippus*.

SAND-WASPS AND THEIR VICTIMS

Drawn by James Hall

PLATE IX.—MUD-WASPS COLLECTING MATERIAL FOR NESTS.

SAND-WASPS AND THEIR VICTIMS

One hot August afternoon, while watching the wasps and bees about a small sand-bank thrown up by the spring torrent of a New England brook, my attention was attracted by a small black wasp apparently digging promiscuously in the level sand. In a moment, however, she came to a concealed burrow, the mouth of which she cleared rapidly with her feet. Then she went to a place a couple of inches away, picked up a young grasshopper lying there in a comatose state, and dragged it down the hole, backing in herself and pulling her victim head first. She came out almost immediately and, facing away from the opening, began scraping sand toward its mouth, using all her feet, more or less, but especially the hind ones. This was continued until the surface was perfectly smooth, with no indication of a burrow. The wasp then turned around two or three times, going over the ground carefully to see, I supposed, that the work was well done and that no tell-tale traces were left. Apparently satisfied on this point, she flew away at 2.35 P.M.

The wasp had been gone but a moment when a little two-winged fly, having the general appearance of the parasites of the family Tachinidæ, appeared upon the scene and ran about over the sand as if looking for something. It continued to move restlessly about for three or four minutes and then flew away. At 2.41 Mrs. Sand-wasp returned, carrying another comatose young grasshopper of a different species from the first. She alighted with her burden about three inches from the concealed burrow, and dragged the victim a little nearer. Then she found the hole, dug out the opening, dragged the grasshopper down head

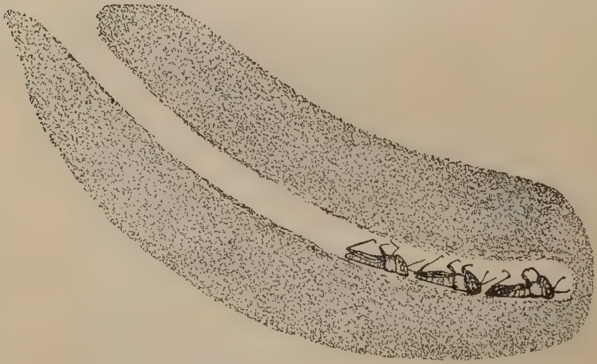


FIG. 54.—Grasshoppers in Burrow of Sand-wasp.

first, came out immediately, covered the mouth of the burrow and flew away, the whole operation occupying just one minute.

The next grasshopper evidently proved harder to find, for the wasp did not return with it till 3.01, the little Tachinid fly having come back in the interim and spent some time in a fruitless examination of the region of the hole. When the wasp returned with her third victim, she placed it on the surface of the sand, found the opening, dug out the sand at its mouth, and dragged the grasshopper down head first. I then put my collecting-bottle over the hole, and three or four minutes later the wasp came out and was caught.

Digging the sand away carefully, I followed up the oblique burrow, which was about three inches long, and ended two inches from the surface. At the bottom lay the three grasshoppers on their backs, each with its head toward the closed end of the burrow. On the neck of the middle one was a small, white, slightly curved, cylindrical egg which the wasp had doubtless placed there during the last visit.

The grasshoppers were taken to the laboratory and placed in a glass tube, in the hope that the egg would hatch and the wasp larva be reared. But the conditions were not sufficiently natural, probably because the atmosphere was too dry, and the grasshoppers gradually shrivelled up. When first brought in they were in a paralyzed condition, unable to walk or jump, although when touched they readily moved their legs and antennæ.

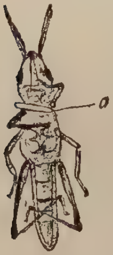


FIG. 55.—Grasshopper, showing Egg of Sand-wasp.

A most interesting chapter of animal evolution was exhibited by these insects during the half-hour thus described. If one knew the processes of development which have led to the little drama thus enacted on that stage of shifting sand, he could solve many biological problems now under discussion. How did the wasp learn that a paralyzed grasshopper would keep from decaying in that hot situation during the warmest portion of the year, so that when the egg hatched into a grub the latter would have fresh and living food right at hand—one grasshopper directly beneath its diminutive nose and another on each side, waiting helplessly to be devoured? And when she knew it, how did she learn to sting to accomplish just the degree of paralyzation required?

Whence also came the prudence which led her to cover up the mouth of the burrow each time she left, thus excluding the little Tachinid fly, which apparently desired to take advantage of the sting with which nature provides the wasp, but not itself? These and many other similar queries come to mind as one thinks of the meaning of the insect's actions; and one almost envies the pre-Darwinian naturalists of fifty years ago to whom everything was so easily explained by the magic of an all-embracing instinct.

Shortly after making these sand-wasp observations I was greatly interested in an account of an experience with another of these little creatures reported by Mr. Theodore Pergande to the Entomological Society of Washington. While on a gravelly slope Mr. Pergande noticed a female sand-wasp, belonging to the genus Ammophila, flying about in a peculiar fashion. Presently it alighted and ran briskly about in every direction with its head close to the ground and the abdomen elevated; while its antennæ were in con-

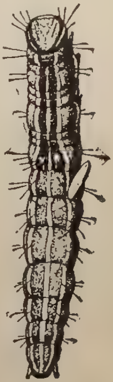


FIG. 56. — Caterpillar, with Egg of Ammophila. (After Pergande.)

stant agitation as if searching for something important, though nothing in any way striking the eye could be seen on the bare sand which possibly could have attracted its attention. Suddenly it stopped at a certain spot, pressed the head close to the ground, and commenced beating the ground with its abdomen, producing at the same time an audible and quite sharp sound similar to *bss*, *bss*, *bss*, tapping with each sound the earth with its abdomen. It continued this performance for some time, running or flying off a short distance twice or thrice during brief intervals. Finally it picked up with its jaws "a small pebble, carried it to the mysterious spot and deposited it on top, pressing the pebble down as much as possible to insure its remaining in position. Running then again a distance away, it picked up another pebble and placed it close to the first one; after a while a third was added. No more pebbles of the desired size being near enough at hand, it ran some distance farther, when it came across a pebble which appeared to suit its purpose; took hold and lifted it, but unfortunately the shape of this little stone was such that it slipped from its jaws. It tried again and again for quite a while to obtain a good hold, though without success, when it left it in apparent disgust. Running about after this failure for some time in search of a more suitable stone, but not finding what was wanted, she returned to her little monument of pebbles, and commenced to rearrange them and press them down as much as possible. After being satisfied that everything was well done, she flew away, not to return."

After the departure of the insect, Mr. Pergande removed the little stones carefully, but could find nothing in the sand immediately beneath them. At a depth of three inches, however, he found a large caterpillar, "as fresh and bright as if it had been placed there a moment before." A small, slightly curved, cylindrical egg was attached to the middle of the caterpillar's body (Fig. 56). This was the egg of the Ammophila. For its protection, and that of the resulting larva, the mother insect had taken the trouble of piling up the pebbles. Possibly she knew of some Tachinid fly or other enemy which could burrow through the sand to the larva, and placed the stones as an obstacle not to be removed.

A still more remarkable case, of what in man we would call reasoning intelligence, has been recorded by Professor S. W. Williston, of the University of Kansas, concerning a species of this same genus Ammophila, which is abundant on the western plains. The absence of trees, houses, fences, and watercourses has driven a much larger proportion of the plains insects to making holes in the ground than is usual in other regions. Consequently the competition is greater, and the struggle for existence more intense. The sand-wasp in question makes vertical holes in the hard-baked surface, carrying the earth removed to clumps of grass in the vicinity. The holes are approximately four inches deep, and for about the first half inch are of a greater diameter than the remaining distance. "When the excavation had been carried to the required depth, the wasp, after a survey of the premises, flying away soon returned with a large pebble in its mandibles, which it carefully deposited within the opening; then standing over the entrance, with her four posterior feet she (I say she, for it was evident they were all females) rapidly and most amusingly scraped the dust with her two front feet 'hand over hand' back beneath her, till she had filled the hole above the stone to the top. The operation so far was remarkable enough, but the next procedure was more so. When she had heaped up the dirt to her satisfaction, she again flew away and immediately returned with a smaller pebble, perhaps an eighth of an inch in diameter, and then standing more nearly erect, with the front feet folded beneath her, she pressed down the dust all over and about the opening, smoothing off the surface and accompanying the action with a peculiar rasping sound. After all this was done, and she spent several minutes each time in thus stamping the earth so that only a

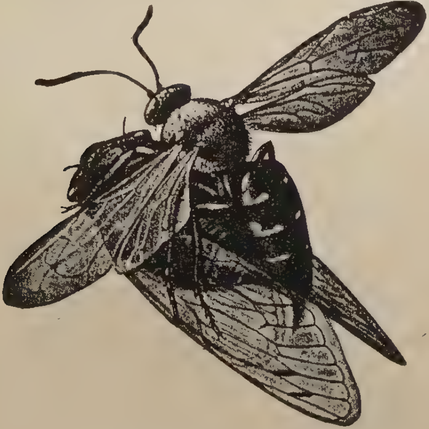


FIG. 57.—Digger-wasp carrying Cicada. (After Riley, Div. Ent., U. S. Dept. Agr.)

keen eye could detect any abrasion of the surface, she laid aside the little pebble and flew away." A few minutes later the wasp returned carrying with difficulty a paralyzed, soft-bodied caterpillar, which was laid on the ground beside the concealed burrow. The latter was then quickly opened and the stone cap withdrawn and laid to one side; the wasp now drags the caterpillar down the hole, and soon emerges to close the opening as carefully as before. Then she flies off in search of another victim. Returning with this, it is also carried to the bottom of the burrow; the little drama is sometimes enacted four or five times before the wasp mother is satisfied that sufficient nourishment has been provided for her unborn progeny.

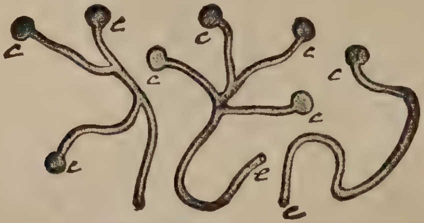


FIG. 58.—Burrows of Larger Digger-wasp. Reduced. (After Riley, Div. Ent., U. S. Dept. Agr.)

These sand-wasps belong to a large and comprehensive family, called by entomologists the

Sphegidæ, which is divided into a number of sub-families that of late have often been raised to family rank. There are a great many genera and species belonging to the group whose life histories, though often quite diverse, are of exceeding interest. Nearly all of them have the curious habit of storing up, as food for the young, living creatures paralyzed by stinging. As a rule, there is decided unity of feeding habits in the various species: some provision their nests solely with young grasshoppers, others with crickets or two-winged flies, many with spiders or caterpillars, and one uses only cicadas as food for her offspring.

On account of the size of the wasp and its victim, no species of the family is more interesting than the Larger Digger-wasp — the *Sphecius speciosus* of naturalists — the life history of which has been admirably described by Dr. C. V. Riley. The wasp chooses as its victim the Dog-day Cicada or Harvest-fly, the large and powerful insect which, during the hot summer days, makes the air vibrate with its noisy song. In the adult state these insects live upon the branches of trees, where they are pounced upon by the female wasps, stung to paralyzation, and with considerable difficulty carried to the neighboring bank, in which the hollow cell has already been prepared. As the wasp is unable to fly upward with so heavy a burden, she sometimes — when in the preliminary struggle both wasp and cicada have tumbled to the ground — laboriously drags it up a tree from whence to start her flight. It also often happens that the burrow is too far off to be reached at a single flight, so that the wasp may have to drag her heavy burden up two or three trees before the desired spot is reached.

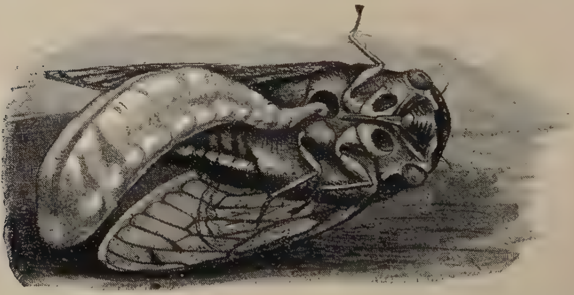


FIG. 59. — Larva of Digger-wasp feeding on Cicada. (After Riley, Div. Ent., U. S. Dept. Agr.)

The burrows of Sphecius are made in dry soil, and have at the end a spherical cell. In this the cicada is placed back downward. The wasp then deposits a long, white egg on the ventral side of the victim. In a few days the egg hatches into a larva that feeds upon the juicy tissues of the cicada, developing so rapidly that in about ten days it is full-grown. It now spins a silken cocoon, within which it passes the winter without changing to the pupa or chrysalis state. This transformation takes place the following spring, and shortly afterward the insect again changes to an adult digger-wasp, thus completing the cycle of existence.

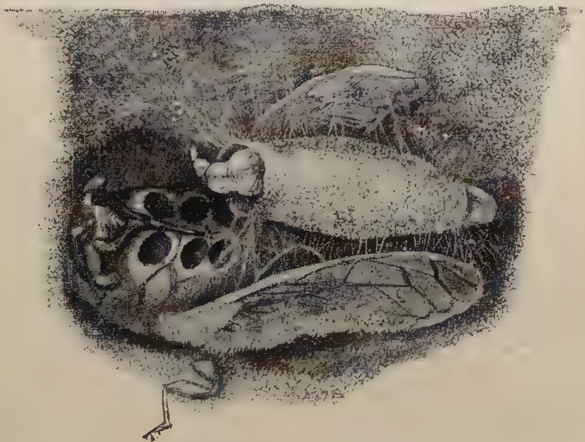


FIG. 60.—Larva of Digger-wasp spinning Cocoon. (After Riley, Div. Ent., U. S. Dept. Agr.)

Besides these so-called sand-wasps and digger-wasps, which make nests in the ground, there are many species of the mud-wasps which fasten earthen nests to wooden supports above ground. Taking the United States as a whole, the most abundant of these probably is the common "Mud-dauber," — a rather large wasp known to science as *Pelopæus cementarius*. It especially abounds in the southern states, where its nests are to be found about houses, barns, and sheds in all sorts of situations. In Florida I have seen deserted shanties almost lined with them.

The adult mud-dauber is about an inch long, black in general color, with distinct yellow markings on the thorax and legs. It constructs nests of earth which it plasters against the corners or sides of wooden buildings. Every one has seen these insects collecting their material about pumps and in other damp places (Plate IX.). Each nest contains several cells which the wasp fills with paralyzed spiders, and in which she deposits her eggs — one to each cell. In due season the egg hatches into a little grub that feeds upon the victims immured in the miniature catacomb in which it is born. It gradually increases in size, and when full-grown as a larva it constructs a thin, brown cocoon within which the transformation to the pupa

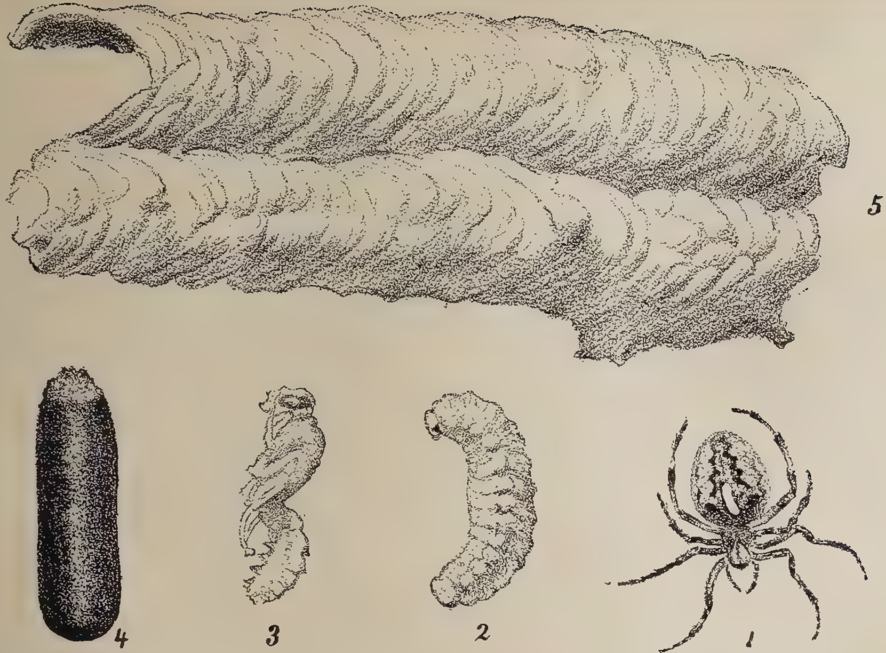


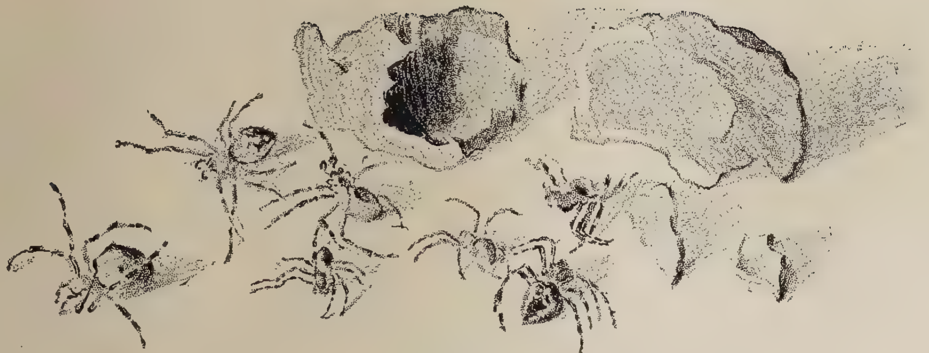
Plate X.—Mud-wasp Cell and Stages of Life: 1, Egg on Spider; 2, Larva; 3, Pupa; 4, Cocoon; 5, Cells.

takes place. Finally, the pupa emerges as an adult wasp which continues the round of life.

There are a great many other insects among these fossorial wasps whose life history is of interest. But the foregoing examples will serve to bring to the reader's attention the more salient points in their biographies; and we may well pass on to a consideration of what, with our present knowledge, seems the most probable manner of development of the remarkable "instincts" displayed.

The most striking of these instincts is that by which paralyzed grasshoppers or other insects are immured in a cell with the egg of the wasp. This has long been celebrated as one of the remarkable examples of insect instinct; and has elicited much speculation as to the method of its development.

There is one genus of these digger-wasps whose life habits are strikingly different from those of its congeners. Our present knowledge indicates that the various species of Bembex do not store up the food of the larvæ in advance as do most of the digger-wasps, but the mother insect continues to provide fresh food for her offspring during its larval existence. For example, the



Drawn by James Hall.

PLATE XI. — CONTENTS OF A MUD-WASP CELL.

life history of the European species known as *Bembex rostrata* has recently been described in detail by a Danish entomologist. The adult does not paralyze the two-winged flies upon which it preys, but, instead, kills them, apparently by biting them on the back with its jaws. A cell about three inches deep is made in solid sand; in this a dead fly is placed with an egg of the Bembex attached to it. When the egg hatches, the larva feeds on the fly, and thereafter the mother insect brings freshly killed flies every day, seeking larger prey as the larva grows. When full-grown, by which time the larva may have devoured eighty flies, it spins a cocoon of silk and sand, within which it eventually changes to a pupa to transform later to the adult condition. Between the visits of the mother insect the entrances to the cells are usually covered with sand: often a small stone is also placed over each opening as an additional safeguard against parasites or other enemies.

This curious habit is very significant to one studying the evolution of the digger-wasps. It gives a starting-point from which to trace the development of the food-storing habit.

There is another genus, allied to Bembex, in which the mother insect prepares a cell and stores it with caterpillars, badly injured but not paralyzed. These lie at the bottom of the cell, and the egg of the wasp is suspended from a silken thread attached to the roof of the cell. "When the young grub is hatched, it suspends itself to this thread by a silken sheath, in which it hangs, head downwards, over its victims. Does one of them struggle? Quick as lightning, it retreats up the sheath out of harm's way."

The next step forward is the paralyzing of the caterpillars by the mother insect. As the wasp would naturally use her sting in attacking her victims, it seems not inconceivable that the combined action of the intelligence of the wasp and the laws of natural selection should lead to the establishment of the hereditary instinct, which we now see displayed, by means of which the wasp stings in just the place or places to produce the desired effect.

THE WHITE-FACED HORNET

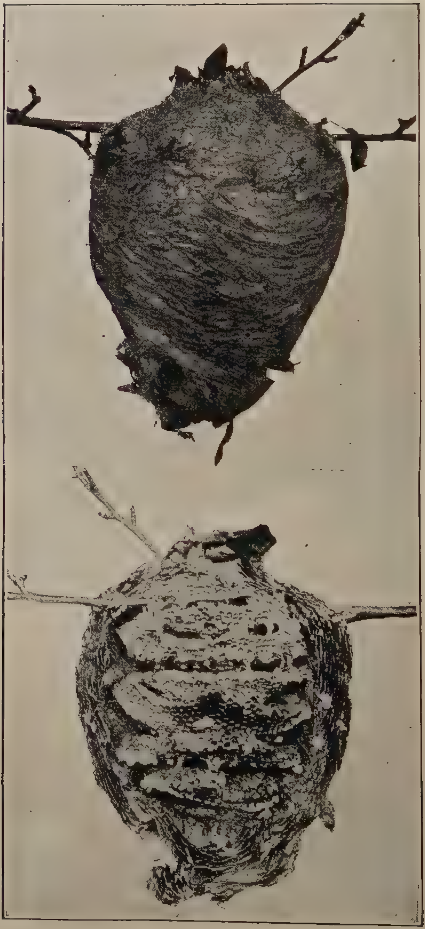


Plate XII.—Nest of Hornet. Lower Figure with Outside removed.

THE WHITE-FACED HORNET

The large spherical or oval nests of the paper-making wasps may frequently be found, during winter, attached to the branches of trees and the larger shrubs. As seen from the outside these nests consist of a gray, paper-like, water-proof substance, evidently put on in thin layers, with an opening at the bottom. Should you open such a nest in winter, there would be found to be a dozen or more of these layers making up the outer covering, while on the inside would be found a series of horizontal combs, one below the other, held together by vertical pillars.

In the winter nest thus torn apart there may sometimes be found one or more large white-faced wasps resembling the figure herewith. These are the females or so-called "queens" of the social insects: no other form lives through the winter.

In spring the queen from such an old nest, whether she has spent the winter in its shelter or elsewhere, starts a new colony by making a few cells and depositing eggs in them. She feeds the larval grubs that hatch from the eggs with finely-chewed insects. In a short time these grubs develop into wasps that resemble the queen in a general way, but are smaller than she is; these are the neuter or worker wasps. These soon take upon themselves the work of feeding the larval wasps and of enlarging the nests, leaving the queen free to devote most of her time to the laying of eggs in the new cells prepared for them.

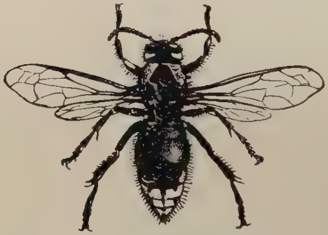


Fig. 61.—The White-faced Hornet. (After Sanborn.)

By this means the wasps increase in numbers very rapidly, so that before many weeks have passed the colony that started with the single queen and a few rude cells has become a large and populous nest.

Early in autumn a brood of true males and females develop in the nest. Mating between these takes place, and the females or "queens" survive the ensuing winter to start new colonies the following spring. The males and workers perish when cold weather comes on.

The young or larvæ of these wasps develop in the cells of the comb, there being one larva to each cell. When full-grown the larva is a whitish, legless grub, having an indistinct head and mouth, and a row of breathing-pores or spiracles on each side of the body: it completely fills the cell. An idea of its form may be obtained from

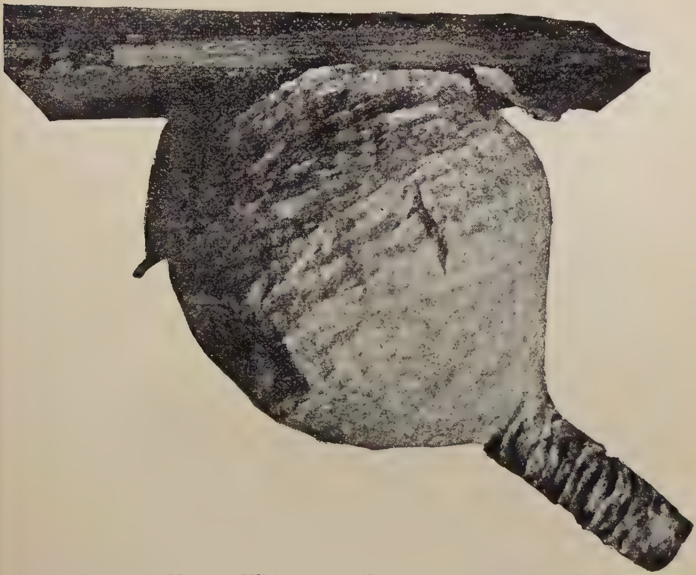


Fig. 62.—Nest of White-faced Hornet just started. (From Smith.)

the upper left-hand figure below, which represents the larva of the European hornet, *Vespa crabro*. The full-grown larvæ are said to spin a cocoon, thereby covering over the end of the cell; the larva then changes to the pupa state, to transform soon afterward into an adult wasp, which gnaws a hole in the cap of the cocoon and emerges. The cells of the males and perfect females or queens are larger than those of the

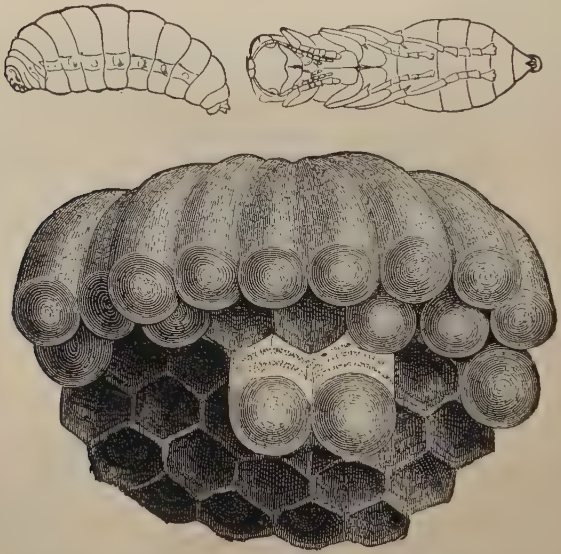


Fig. 63.—Larva, Pupa, and Comb of European Hornet. (From *Riverside Natural History*.)

workers, as may be seen in the middle of the comb shown in Fig. 63.

The nests of these insects are made of a papery substance, manufactured by the insects from woody tissue torn from the surfaces of weather-beaten boards, logs, and stumps. Such woody substances appear to be chewed into fine pulp more or less mixed with the secretions of the mouth, and then spread out in thin tissue. Nearly fifty years ago Professor B. Jaeger, in discussing the ability of the wasps to make paper from wood, said: "It would be interesting, and possibly might be made very profitable, to institute experiments with the wood from which these insects manufacture their paper, for if a new material for the manufacture of paper could thus be discovered, the fortunate discoverer would be well repaid, and the country would really be enriched by possessing another source of revenue, and we should not be obliged to import so many rags from Trieste and other Austrian seaports." Since this was written the hint of the wasps has been acted upon; a vast amount of paper is now made by man from wood reduced to a pulp, and then spread out in thin sheets.

It is interesting in this connection to note an observation recorded by Miss Mary E. Murtfeldt, regarding the related Rust-red Social Wasp,[1] a common species in the South. In the region around St. Louis, Mo., paper bags are largely used in protecting clusters of grapes from rot. This wasp has discovered that the material of these bags is useful for making its nests, probably being easier to work over than the

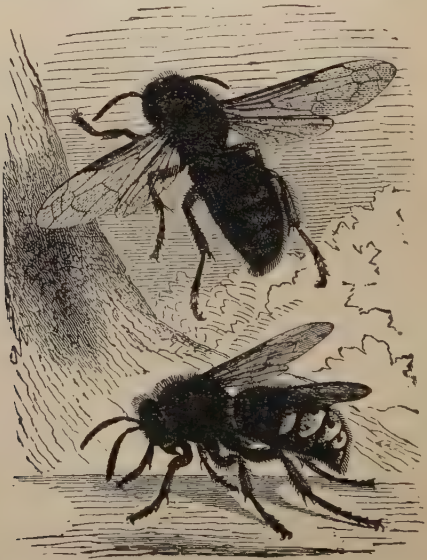


FIG. 64.—European Hornets. (From *Riverside Natural History*.)

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[1] *Polistes rubiginosus*.

usual weatherbeaten wood, and many of the wasps use the former instead of the latter. When at work upon one of the bags, the wasp works energetically, stripping off, "with its jaws, fibres and layers of the paper. These are rapidly gathered, by the aid of the front tarsi, into a compact packet and finally borne away."

The adult wasps feed freely upon a great variety of insects which they catch alive. They may commonly be seen visiting clusters of flowers to which flies and other insects are attracted, many of which fall victims to Vespa's rapacity. Sometimes the flies are devoured at once, while at others the wasp flies away with her prey. Mr. James H. Emerton has described and figured one of these wasps in the act of eating a fly while hanging by one foot attached to a twig. "The half-eaten fly was held by the front feet, while the other legs and wings stuck out carelessly in all directions. As the mandibles or jaws and antennæ kept in rapid motion, and the fly was turned over and over by the fore feet, the wasp swung slowly back and forth with the same appearance of enjoyment and comfort as a man eating an apple in a hammock." After the repast the wasp climbed upon the twig and flew away. Another observer has described an experience along the shores of Lake Superior: "I was much amused there one day in the month of August, while at work in my tent, watching these Bald-faced Hornets on their foraging expeditions, catching flies to feed their young. The easy grace with which they catch a fly while on the wing is truly wonderful. To select a fly and pounce upon it, dexterously seizing it, is the work of an instant. The wasp then alights and prepares its victim for transportation, trimming it by cutting off the limbs, as superfluities which would encumber the return flight. One by one

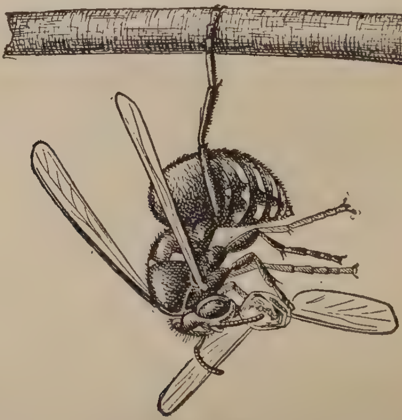

FIG. 65. — Wasp eating a Fly. (After Emerton.)

drop down the slender legs of the fly, and the gauzy wings flutter away, as neatly nipped off as though done with tiny scissors. Next, proceeding to roll the denuded fly into a compact pellet, the wasp moistens it with the saliva for this purpose, and finally flies off suddenly and rapidly to its nest with its prey."

The wasps are by no means confined to living insects for their food. They may nearly always be found in abundance about trees or shrubs thickly infested with aphides or plant-lice, where they feed upon the liquid "honey-dew" excreted by these insects. They also are likely to be seen sipping the sap from injured trees or new stumps.

Two or three years ago I was much interested in the competition between several of these wasps and several ruby-throated humming-birds, for the possession of the sap flow of a young birch which had been pierced by a yellow-bellied woodpecker. These wasps are also fond of the juices of fruits, and congregate upon fallen apples, pears, peaches, or plums. They attack ripe grapes upon the vine, biting through the skin and feeding upon the juices. They also devour various other substances, being as nearly omnivorous as such creatures can be.

The White-faced Hornet belongs to the family *Vespidæ*, of the order Hymenoptera, and is technically known as *Vespa maculata.* It is closely related to the common Yellow-jacket, the nests of which are generally built underground.

THE MICROGASTER FLIES

THE MICROGASTER FLIES

The species of one large group of ichneumon flies have long been familiarly known under the name of Microgaster flies, *Microgaster* being the genus to which they were all referred until recently, when the two additional genera *Apanteles* and *Microplitis* were established. The members of this sub-family are small, blackish, four-winged flies, having hairy eyes and eighteen-jointed antennæ: they are generally about one-eighth of an inch long, and never longer than one-fourth of an inch.

The great majority of the Microgasters are parasitic upon the caterpillars of butterflies and moths. As a convenient example to illustrate their life history, we may take the species which preys upon the common Grape-caterpillar,[1] represented in Fig. 66. The adult Microgaster fly deposits great numbers of minute eggs beneath the skin along the back of the partially grown caterpillar. In a short time these eggs hatch into small grubs which absorb the fatty juices of the caterpillar, avoiding the vital parts, and growing wholly at the expense of the tissues of the host. Before very long the Microgaster larvæ become full-grown; they then bore holes through the skin of their host and emerge to spin silken cocoons along his back. Within these cocoons they change to pupæ, and in due time transform again to adult flies, gnaw out of the cocoon, and go forth to continue the cycle of existence by finding other caterpillars to victimize.

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[1] *Chœrocampa pampinatrix.*

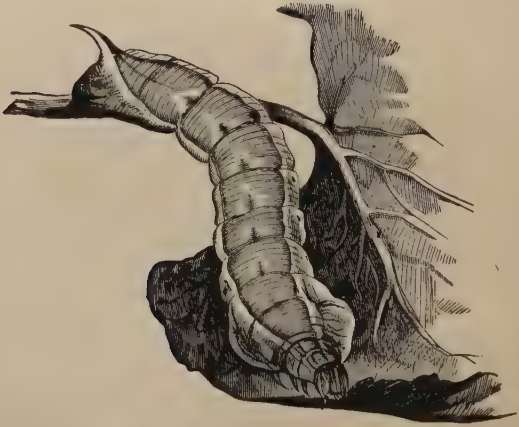

Fig. 66.—Healthy Grape-caterpillar. Natural size. (After Riley.)

About the time the Microgaster larvæ become full-grown, the host stops eating, and when they emerge as a wriggling mob upon its body, it shrinks very considerably in size. The difference between a healthy caterpillar and one bearing the cocoons is well shown by comparing Fig. 66 with Fig. 67.

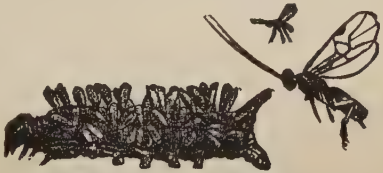

FIG. 67. — Shrunken Grape-caterpillar, with Cocoons. Fly, natural size and magnified, at right. (After Riley.)

"It is one of those remarkable and not easily explained facts," writes Dr. C. V. Riley, "which often confound the student of nature, that while one of these caterpillars, in its normal and healthy condition, may be starved to death in two or three days, another that is writhing with its body full of parasites will live without food for as many weeks. Indeed, I have known one to rest for three weeks in a semi-paralyzed condition, and after the parasitic flies had all escaped from their cocoons, it would rouse itself and make a desperate effort to regain strength by nibbling at a leaf that was offered to it."

The cocoons of a majority of the species of

Microgasters are white and silky, but many are yellow, and some, especially those belonging to the genus Microplitis, are brown and leathery. Some species spin their cocoons singly or in rows along the back of the host, while others leave the host and form them in a mass of silk on some leaf or other object.

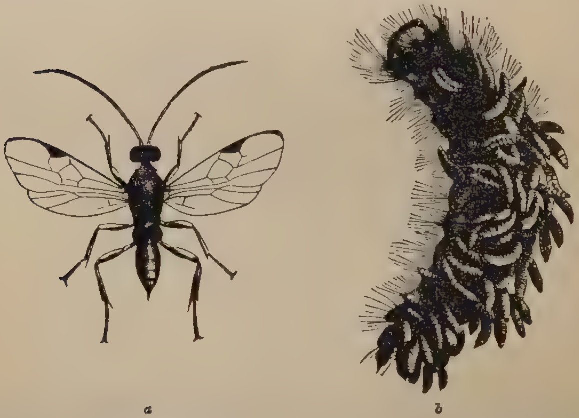

FIG. 68.—*a*, Microgaster, Magnified; *b*, Larvæ of Microgaster emerging from a Caterpillar. (From *Riverside Natural History*.)

The way in which the cocoons of the kind first mentioned are spun has been observed by Mr. J. P. Marshall, who states that the first act of the Microgaster larva, upon emerging from the caterpillar, is to attach its posterior end to its host by some silken threads. It then forms a series of loops of silk, moving its head alternately from left to right, and then from right to left. After spinning to the top of the cocoon, the larva reverses its position, so as to rest with its head down, when it spins to the other side of its cocoon, gradually contracting its body as the work proceeds; and finally, to complete the enclosure of the cocoon, again reversing its position.

As an example of the class which leave their host before spinning the cocoon we may take the parasite (*Apanteles aletiæ*) which preys upon the cotton-worm. This species spins its cocoon recumbent on the leaf of the plant. The process has been described by Mr. H. G. Hubbard. "In quitting its host the parasite maintains its connection therewith by means of a single thread. After crawling to a distance of about half an inch, it fastens this thread to the surface of the leaf and begins its cocoon. The larva forms the exterior by throwing out loops of ropy fluid, which under the lens are seen to become rigid as they fall, and to harden rapidly, forming a rather coarse strand of white silk which is often beautifully furred. These loops are piled one upon another, and the walls of the cocoon rise rapidly until they meet overhead. The inside is then lined in the manner usual with lepidopterous larvæ, until the whole has become opaque.

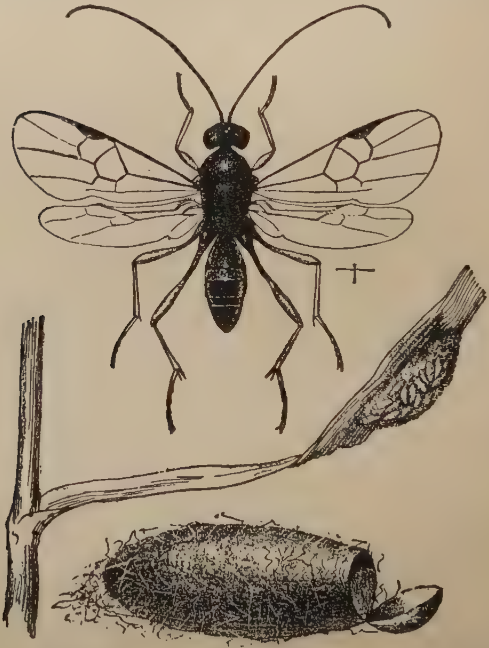

Fig. 69.—*Microgaster glomeratus;* Fly and Cocoon, Magnified; Mass of Cocoons, Natural Size. (After Riley.)

The process of spinning occupies about two hours' time."

Frequently several hundred Microgaster cocoons may be found upon a single caterpillar; a case is on record of one thousand of them being taken from a Bombycid caterpillar in Ceylon.

In the mine of the Apple-leaf Tent-miner[1] there may frequently be found a smooth silken cocoon, having projecting from each end a cord of fine silken threads which are fastened to the sides of the leaf-mine, thus suspending the cocoon after the manner of a hammock. The cocoon is white, with a darker appearing central band, about one-sixth as wide as the cocoon is long. The darker appearance of this band is due not to any difference in the color of the silk, but because the cocoon is there very much thinner than at the ends. The advantage of the peculiar method of suspension is probably to be found in the fact that the cocoon is thus much freer from moisture than it would be were it in contact with the sides of the leaf. These cocoons are made by the maggot of a Microgaster fly,[2] which develops at the expense of the leaf-mining larva.

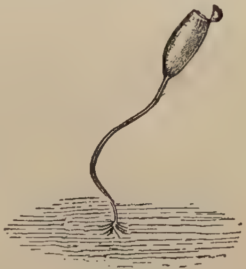

FIG. 70.—Stalked Cocoon of a Microgaster. (After Marshall.)

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[1] *Ornix geminatella* Packard.

[2] *Apanteles ornigis* Weed.

A cocoon, even more curious in its structure, has been described and illustrated by Mr. E. A. Marshall, whose figure of it is reproduced in Fig. 70. This is a stalked cocoon made by *Apanteles formosus*, held up above its place of attachment; the occupant emerges from the upper end as shown by the circular cap. Such cocoons are of great interest because they show so wide a variation in the cocoon-making habits of the family, and the ability of these seemingly stupid maggots to become adapted to special conditions of existence.

THE PARASITE OF THE SPOTTED LADYBIRD-BEETLE

THE PARASITE OF THE SPOTTED LADY-BIRD-BEETLE

In the middle and western states, where the Spotted Ladybird-beetle[1] is abundant, one may sometimes see one of these beetles crouching over a small brown silken cocoon. Sometimes the beetle when found will be dead with its feet entangled in the meshes of the silk; others will be alive and straddling the cocoon. One such, observed in Illinois several years ago by Mr. C. A. Hart, acted much as a spider does with reference to its egg-sac. When found, the beetle's hind claws were caught in the loose silk of the cocoon; when the latter was removed, the beetle seemed greatly disturbed, and would fold its legs about

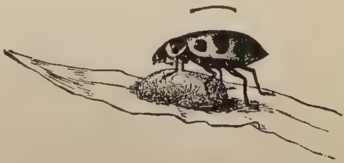

FIG. 71. — Ladybird-beetle, with Cocoon of Parasite. (After Riley, Div. Ent., U. S. Dept. Agr.)

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[1] *Megilla maculata.*

anything within reach. It walked holding its body high in the air, and when it came near the cocoon, the claws would become entangled, so that it dragged the cocoon along after it. When the beetle was placed upon its back it waved its feet excitedly, as most insects do when in this position; but as soon as the cocoon was placed within reach, the beetle folded its legs about it and became quiet, remaining so although still lying upon its back.

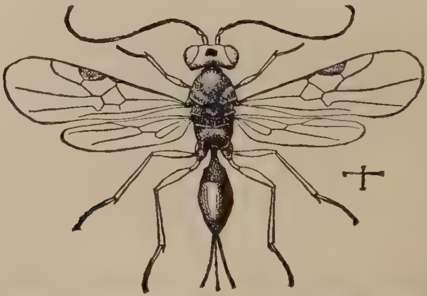

Fig. 72.—Adult of Lady-beetle Parasite. (After Riley, Div. Ent., U. S. Dept. Agr.)

If such a beetle is kept beneath a tumbler or in some closed vessel, one is likely to find in a few days that the beetle is dead and that a small, black, four-winged fly has emerged from the cocoon by gnawing off a cap at one end. This fly is a parasite: it developed from an egg laid some time before — probably in the fully developed beetle — by a similar four-winged fly. The egg hatched into a tiny grub that lived in the abdomen or hind part of the beetle, absorbing the tissues of the host as it developed. After a few weeks of such growth it became full-grown; it then burrowed its way out of the beetle's body and spun a cocoon beside it. Within the cocoon the larva changed to a pupa, to emerge a short time afterward as an adult fly. The beetle lingers on in a half-paralyzed condition for some time before it finally dies.

This parasite is of special interest because it develops in the adult stage of an insect having complete transformations. Most parasites mature in the earlier stages of such insects, instances like this being comparatively rare. This parasite belongs to the family *Braconidæ* of the order Hymenoptera; it is technically known as *Perilitus americanus*.

THE PLANT-LICE PARASITES

THE PLANT-LICE PARASITES

In nearly every colony of plant-lice, especially late in the season, there occur peculiarly inflated specimens that are likely to puzzle the uninitiated observer. Should such specimens be placed in a small vial or a covered tumbler, a short time afterward one is likely to find a round hole in the top of the inflated abdomen, and a tiny four-winged insect flying around in the vial or tumbler. The evidence indicates that the fly developed within the aphid's body; and the observation calls to mind those lines by Aldrich:

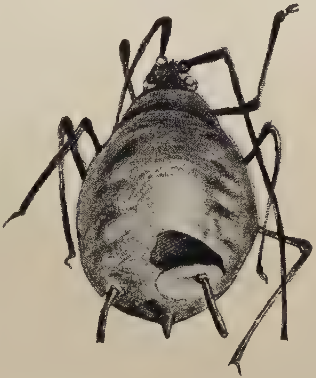

Fig. 73. — A Parasitized Aphis. Magnified. (After Howard.)

> "There is no little thing in nature; in a raindrop's
> compass
> Lie a planet's elements."

The life history of this tiny parasite is very similar to that of the larger species. The female fly alights upon a leaf and runs about among the plant-lice. When she has selected one in which to oviposit, she stands with her head towards it, and bending her abdomen under her thorax between her legs, she darts her ovipositor forward into the body of the aphis. The egg thus so cleverly placed soon hatches into a maggot that lives the lazy life of the parasite, absorbing day by day the body juices of its host, constantly increasing in size until the host is killed, and its body is utilized as a cocoon for the parasitic maggot when it changes to a pupa. In a few days an-

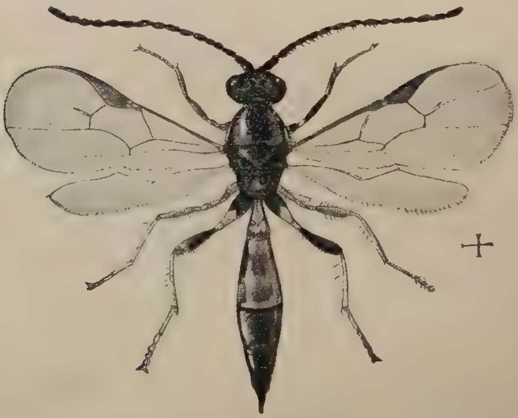

FIG. 74.—An Aphidius Fly. Magnified. (After Howard.)

other transformation occurs; the pupa becomes a four-winged fly which gnaws a circular opening in the top of its 'cocoon,' and emerges to fly away.

There are many different species of these diminutive parasites. Perhaps the most typical genus is *Aphidius*, belonging to the family *Braconidæ.*

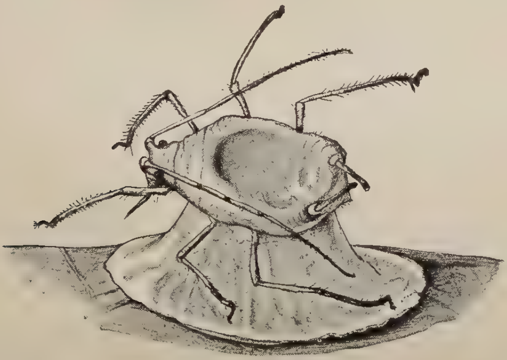

FIG. 75.—Cocoon of Praon beneath Dead Aphid. (After Howard, Div. Ent., U. S. Dept. Agr.)

This is the type-genus of the sub-family *Aphidiinæ*, which contains several other genera. One of the most interesting of these is the genus *Praon*, the larvæ of which develop in plant-lice, and when ready to pupate spin a flattened cocoon beneath the body of the host, the host and cocoon resembling Fig. 75 when magnified. This parasite is itself preyed upon by another still smaller parasite, which destroys it as it destroyed the aphid.

THE TACHINID PARASITES

THE TACHINID PARASITES

LAST spring I found under an oak tree a fine cocoon, apparently made by the larva of the beautiful Polyphemus Moth,[1] one of the largest and handsomest American insects. It was kept in-doors in a glass-covered box in the hope that some time in May or June the moth would appear. But on looking into the box one morning early in summer, I saw a round hole in the brown cocoon, and eight or nine oval brown cases scattered about near the end of the cocoon. One of

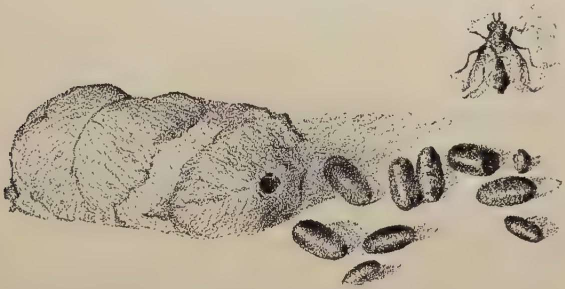

FIG. 76.—Cocoon of Moth with Pupæ and Adult Parasite.

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[1] *Telea polyphemus* Linn.

these cases had a cap broken off at the end, and near it stood a two-winged fly apparently freshly emerged from the pupa. It was at once evident that no moth would come from that cocoon, for these were parasites that had developed in its stead.

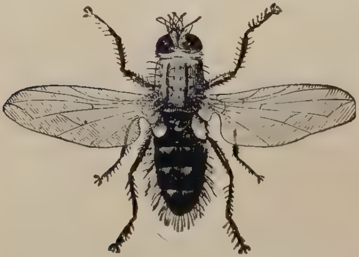

Fig. 77. — A Tachinid Fly. Magnified. (After Riley).

When the caterpillar which had spun the cocoon was partially grown there had alighted upon its back a buzzing fly, similar, in general appearance, to Fig. 77, which had glued to the skin several small, oval, whitish eggs. A few days afterwards each of these eggs hatched into a tiny maggot that had burrowed through the skin of the caterpillar, and developed in its body, absorbing the fatty juices as the maggot grew. These maggots were true internal parasites, and the caterpillar was their unwilling host. The latter became full-grown and was able to spin a cocoon before the parasites killed it. Then they matured, and worked their way out through the cocoon; at this time they were whitish, footless grubs. Their outer skin soon hardened, turning to a deep chestnut-brown color: within the pupa-case thus formed, the maggots changed to pupæ. About ten days later they again changed to two-winged flies, like the one which laid the eggs upon the caterpillar; the pupa-cases cracked open near one end, and a fly emerged from each.

This, in brief, is the life history of the members of the large family of parasites known as *Tachinidæ.* They are among the most beneficial of insects, destroying immense numbers of army-worms, cutworms, and various other noxious caterpillars. The adult flies get their food from flowers; they bear a general resemblance to the common house-fly.

THE HIBERNATION OF APHIDES

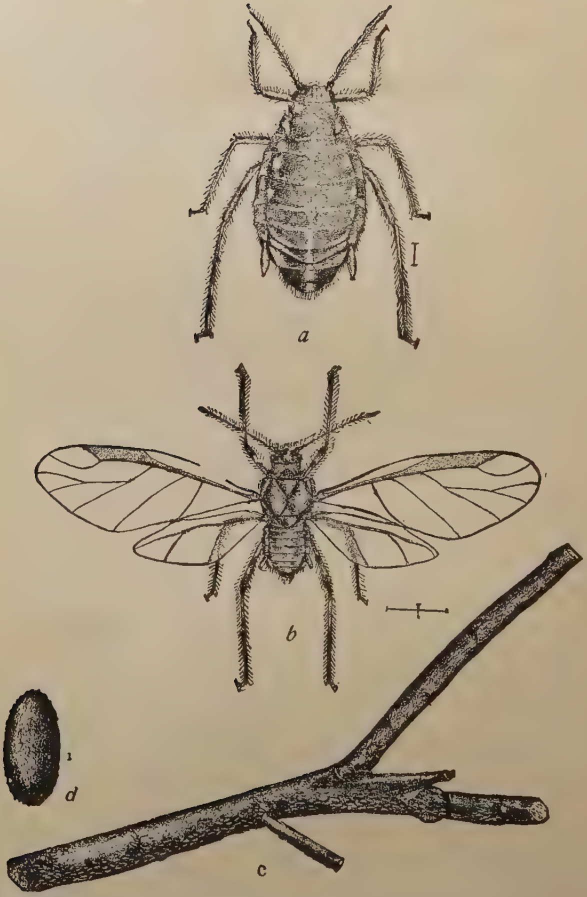

Plate XIII.—Spotted Willow Aphis: *a*, Oviparous Female; *b*, Winged Male; *c*, Eggs on Bark; *d*, Eggs; *a*, *b*, *d*, Magnified.

THE HIBERNATION OF APHIDES[1]

In latitudes where winter is a period of protracted cold, a successful mode of passing through it is of first importance to all animals that cannot follow the swallow with the changing season. Such creatures must not only endure the low temperatures to which they are subjected, but also must so protect themselves that a certain proportion of them, at least, shall escape the attacks of the various enemies that are abroad during this long period of forced inactivity. With insects, successful hibernation is of vital importance, and each species appears to have chosen (largely through the action of natural selection) the safest method of passing through. A vast number of them hibernate in the egg state; many in the larval state; many as pupæ; and a considerable proportion as adults. Not infrequently the same species may hibernate in two or more of these conditions. In such cases it is evident that if the insect in one stage suffers more loss than in the other, the latter — other things being equal — will gradually replace the former as the hibernating condition.

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[1] Annual address of the retiring president of the Cambridge Entomological Club, 14 February, 1896. Reprinted from *Psyche*.

The aphides furnish an interesting illustration of the various methods the different species of a single family may adopt to pass the winter. The normal life history of these little creatures may be briefly summarized as follows. In the spring there hatches from an egg, deposited the autumn previous, a little aphid that sucks the sap of its food plant for a number of days — sometimes a fortnight — before it becomes full-grown. During this period of growth, it moults or sheds its skin a number of times to provide for its rapidly increasing size. This insect is sometimes called the stem-mother. She is always wingless. Soon after reaching maturity she commences to give birth to living young, continuing the process usually for several days. These young are most commonly born naked, but in some species they are surrounded by a thin pellicle which ruptures soon after birth. They resemble the stem-mother in general appearance, being of course much smaller. Each soon begins sucking sap on her own account, and in the course of ten days or a fortnight becomes mature. It then begins bringing other aphides into the world: these soon mature and give birth to a third generation. All of the individuals of these early broods are parthenogenetic females, giving birth to living young without the presence of males. Many of them are provided with wings, but the majority are wingless. This method of reproduction is continued throughout the warm season, but on the approach of cold weather a true sexual generation is produced, the males of which may be either winged or wingless, while the females are always wingless. Sexual union between these two forms takes place, and the females deposit true eggs. These pass through the winter, and in spring hatch into stem-mothers, which renew the cycle of existence.

The great majority of aphides pass through the winter in the egg state. This is doubtless the safest way; for even supposing the viviparous or sexed forms capable of enduring intense cold, they would be much more liable to be eaten by birds, scattered by winds, or washed away by floods, than the eggs. The latter are nearly always partially secured at least against these vicissitudes, although doubtless millions of them perish from exposure to the elements, or are gobbled up by the hungry beaks of chickadees and other winter birds. But as a rule the eggs are so small and so carefully stowed away, that a sufficient number to propagate the species survive all perils.

Perhaps as simple a method of providing for the eggs as any is that adopted by a handsome yellow Callipterus (*C. discolor* Monell) which I studied in Illinois a few years ago. This species lives on the under side of oak leaves, particularly the Burr Oak (*Quercus macrocarpa*), generally in limited colonies. In autumn a sexed generation is produced, the males having wings and the oviparous females being provided with a long, tapering ovipositor, by means of which they push the eggs through the dense pubescence on the under side of the leaf, generally fastening it firmly against the mid-rib. Many of these leaves remain on the tree until quite late in spring; and it is fair to presume that a sufficient proportion of the aphides hatch before the leaves fall off, climb upon the twigs and begin sucking at the buds, although this has not so far as I know been observed. The eggs are certainly safer, hidden in the pubescence of the leaves, from observation by birds, than they would be upon the twigs.

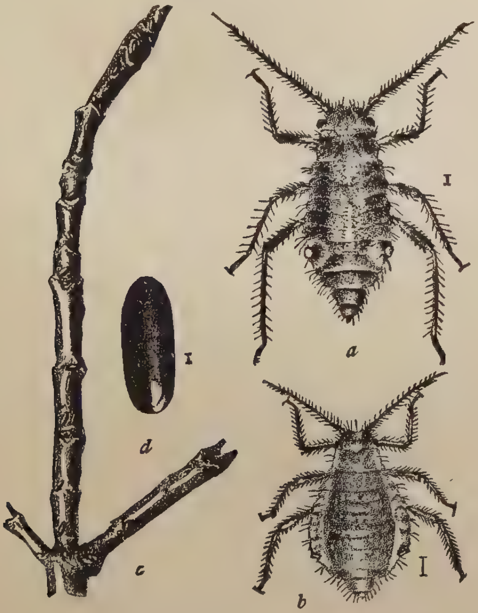

FIG. 78.—Box Elder Chaitophorus: *a*, male; *b*, female; *c*, eggs on twigs; *d*, egg; *a*, *b*, *d*, magnified.

From fastening the egg to the leaf to attaching it to the bark of a twig is a short step, and one which appears to have been taken by a majority of the aphides affecting trees and shrubs. In many cases it has naturally resulted from the insects being compelled to migrate to the twigs by the early falling of the leaves. In many of the states in the valley of the Mississippi and its tributaries where the Box Elder or Ash-leaved Maple (*Negundo aceroides*) is abundant, its foliage is often infested by a small aphid of the genus Chaitophorus (*C. negundoides*). In autumn the sexed forms leave the falling leaves and congregate in great numbers on the twigs. The males are wingless little creatures with slender flattened bodies, barely two millimeters in length, and long legs and antennæ. The egg-laying females are larger and have much broader bodies. They deposit their eggs irregularly upon the bark of the twigs, especially about the buds. The eggs are elliptical-ovoid, less than one millimeter long, greenish or yellowish brown when first laid, but gradually changing to shining black.

There is a pretty little aphis (*A. euonymi*) living upon the under surface of the leaves of the shrub called Burning Bush (*Euonymus atropurpureus*). In autumn the oviparous females congregate on the twigs and deposit their eggs in the crevices about the buds. A curious little Phyllaphis (Fig. 80), that I found commonly on the leaves of beech in central Ohio a few years ago, also repairs to the bark for oviposition, but is much more careful in concealing the eggs. The viviparous colonies are found late in summer and early in autumn on the under sides of the leaves, with more or less flocculent matter about them. The sexed forms develop during October, and the oviparous females wander over the bark of the twigs, limbs, and trunk, in search of crevices in which to deposit their eggs. When a suitable place is found, the egg is laid, and is then driven into position by the following method. The insect so places herself that her hind legs easily touch the egg; then standing on her four front legs, she brings the two hind ones down upon the egg in rapid succession, striking with considerable force. This serves the double pur-

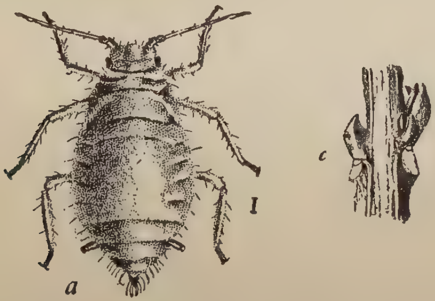

FIG. 79.—Burning Bush Aphis: *a*, oviparous female, magnified; *c*, eggs beside buds.

pose of pushing the egg into place, and of drawing out a viscid secretion with which it is covered into a thread-like, silvery film, so similar to the surrounding bark that it is difficult to detect the difference. A minute and a half to two minutes are spent in this process.

Recent observations have shown that a number of species of aphides live upon various trees during autumn, winter, and spring, but for the summer season migrate to more succulent herbaceous plants. The best authenticated example of this is the Hop Aphis (*Phorodon humuli*), which was carefully studied both in Europe and America by Dr. C. V. Riley. The life history of the species is briefly this. The insect passes the winter in the egg state on plum trees. In spring

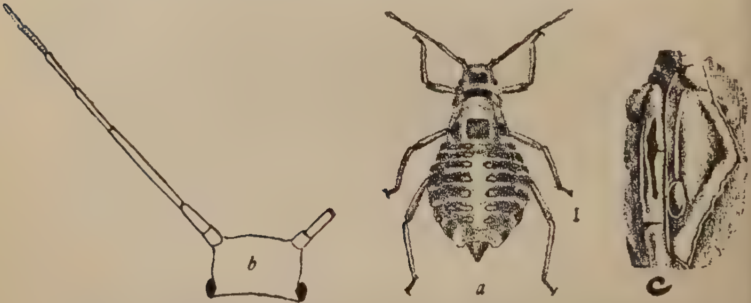

FIG. 80.—Beech Aphis: *a*, oviparous female, magnified: *c*, egg on bark.

each egg hatches into a small aphid that sucks the sap from the expanding leaves. This is the so-called stem-mother. She becomes full-grown in a week or two and then begins bringing forth living young at an average rate of about three each day, continuing the process until she has become the mother of a hundred or more rapidly developing aphides. Each of these in turn gives birth to other young in the same way. Three generations of these parthenogenetic forms are produced upon the plum, the last becoming winged and deserting the trees to search for hop plants. On finding them, these winged migrants light upon the under sides of the leaves, where they start colonies; and the species continues developing upon the hop plant throughout the summer. In early autumn another winged generation is produced, that migrates back to the plum (on which account these forms are sometimes called return-migrants), where each settles upon a leaf and gives birth to three or more young that develop into sexual oviparous females. About the same time winged males are produced upon the hops. They also migrate to the plum, where they mate with the oviparous females. The latter deposit the winter eggs upon the twigs about the buds; and on the advent of cold weather all forms but the eggs perish. There is no doubt that a considerable number of the aphides commonly affecting trees and shrubs have a somewhat similar history. For instance, our common apple aphis (*A. mali*) spends the summer upon grasses, where they continue breeding until autumn, when they return to the apple, and the winged females establish colonies of the wingless egg-laying form upon the leaves. The males fly in from the summer host-plant. The eggs are then laid on the twigs and buds, and the cycle for the year is completed.

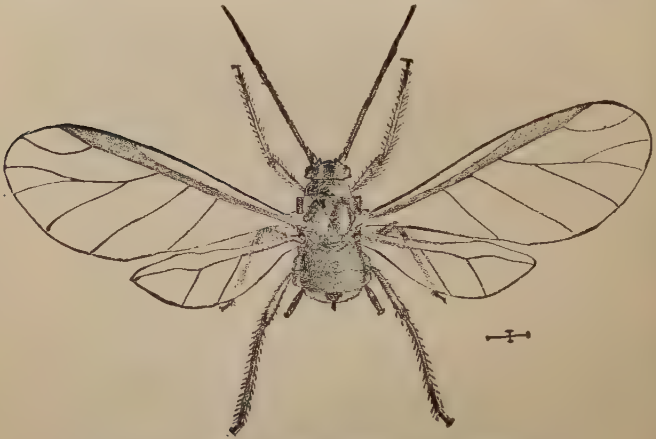

FIG. 81.—Cherry Aphis: winged male. Magnified.

The aphid commonly affecting cherry trees (*Myzus cerasi*) has a similar history. It winters over on the twigs in the egg state. Early in spring the young aphides hatch and crawl upon the bursting buds, inserting their tiny sap-sucking beaks into the tissues of the unfolding leaves. In a week or ten days they become full-grown and begin giving birth to young lice, that also soon develop and repeat the process, increasing very rapidly. Most of the early spring forms are wingless, but during June great numbers of the winged lice appear, and late in June or early in July they generally leave the cherry, migrating to some other plant, although we do not yet know what that plant is. Here they continue developing throughout the summer, and in autumn a winged brood again appears and migrates back to cherry. These migrants give birth to young that develop into egg-laying females which deposit small, oval, shining black eggs upon the twigs.

While the aphides affecting deciduous trees commonly live upon the leaves and deposit eggs upon the buds, the rule is reversed in the case of some species found upon conifers. For instance, the large Lachnus (*L. pini*) occurring upon the twigs of Scotch Pine deposits eggs in longitudinal rows upon the leaves (Fig. 82). The handsome White Pine Lachnus (*L. strobi*) also has a similar habit. Like most plant-lice, this species reproduces viviparously, or by giving birth to living young, during the summer, but on the approach of cold weather the sexual individuals are produced. During October these are usually the only forms present, the oviparous females being congregated in great numbers upon the bark of the smaller branches, with their heads directed towards the trunk of the tree. When disturbed they move about rapidly, usually at-

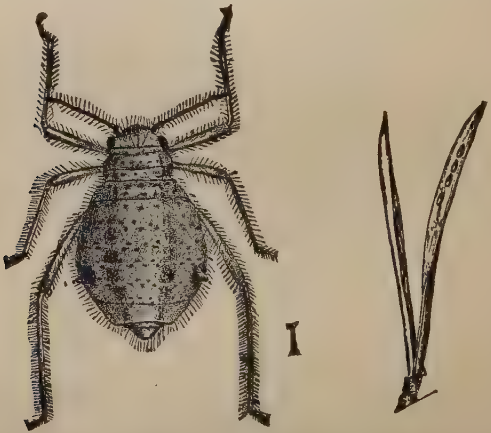

FIG. 82.—Pine Lachnus: oviparous female, magnified, and eggs on leaf.

tempting to conceal themselves on the other side of the branch. At such times they also wave their long hind legs in the air, probably to frighten away predaceous or parasitic enemies. The males are winged, and the oviparous females wingless. The eggs are deposited in longitudinal rows on the White Pine leaflets. Each egg is not quite one-tenth of an inch long, elongate-oval, brownish when first extruded, but soon changing to shining black.

Besides the aphides living upon leaves and ovipositing upon twigs, and those living upon twigs and ovipositing upon leaves, there are many species which both live and oviposit upon the twigs. Several such forms occur upon willow, the prettiest one being the Spotted Willow Aphis (*Melanoxanthus salicis*). This insect lives over winter in the egg state on the bark of willow twigs. Early in spring the eggs hatch into young plant-lice which insert their tiny beaks into the tender bark and suck out the sap. They grow rapidly, and each one soon becomes the mother of several young aphides. The generation from the egg are all wingless, but those of the second generation probably develop into both winged and wingless forms, which are also vivip-

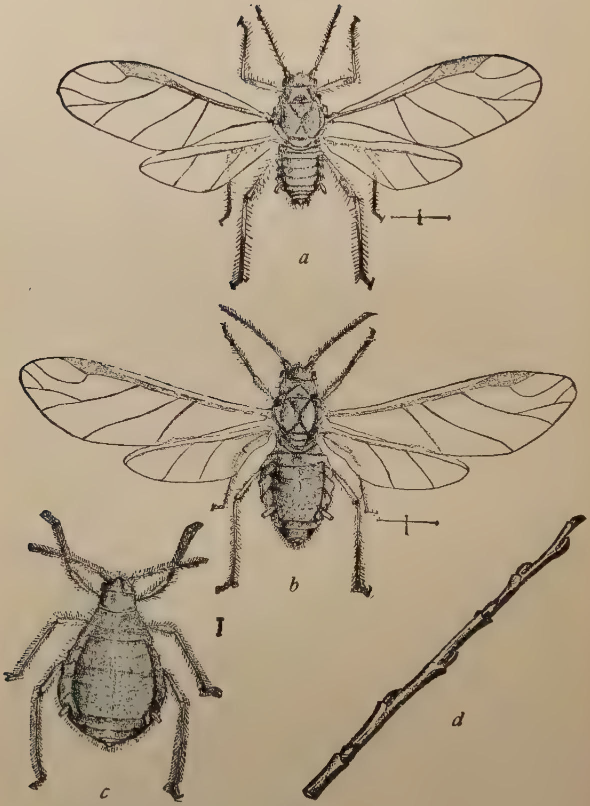

Plate XIV. — Willow Grove Aphis: *a*, Winged Male; *b*, Winged Viviparous Female; *c*, Oviparous Female; *d*, Eggs beside Buds. *a*, *b*, *c*, Magnified.

arous. Successive broods continue to appear throughout the entire summer, all being viviparous, and some having wings while others have none. By midsummer they have often increased so enormously as to cover all the twigs of infested trees, making them appear filthy and unsightly, as well as impairing their vitality by extracting the sap. In autumn a sexed generation is produced, the males of which may be either winged or wingless. In Ohio I have found only winged males, while in New Hampshire I found both forms, the apterous ones being much the more abundant. The oviparous females congregate in one or a few places for purposes of oviposition. In such situations they often cover the bark with their eggs. When first laid each egg is coated with a sticky liquid that dries into a thin, grayish, irregular covering, closely resembling the willow bark in appearance.

Another species, closely resembling the spotted one, and called the Flocculent Willow Aphis (*M. flocculosus*), lives upon the gray willow in flocculent colonies, so closely resembling the bark that they are difficult to detect. The males of this species are wingless. The oviparous females seem to take more care than do the spotted ones in depositing their eggs in the crevices of rough bark where the peculiar whitish covering of each helps greatly to conceal it (Fig. 83).

There are two other aphides of the genus Melanoxanthus which live upon willow twigs but differ from those mentioned above in habits of oviposition. The Bicolored Melanoxanthus (*M. bicolor*) is a rather rare species found in many of the western states. The males are winged, and the yellowish-brown oviparous females deposit their eggs in the crevices about the buds: the latter after a short exposure to the air become shining black with none of the flocculent covering

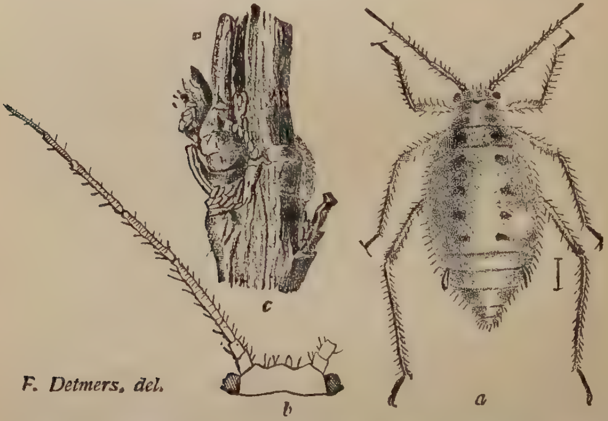

Fig. 83.—Flocculent Willow Aphis: *a*, oviparous female; *b*, head and antennæ; *c*, eggs on twig. *a*, *b*, magnified.

found on the eggs of the other species. The most abundant member of the genus is that sometimes called the Willow Grove Aphis (*M. salicti*), which is similar to the spotted form, but without the conspicuous white spots. It lives in large colonies on the twigs and branches. The winged males and oviparous females develop in autumn, and the latter oviposit on the twigs about the buds (Plate XIV.).

One of the largest aphides living upon twigs is the Sycamore Lachnus (*L. platanicola*), which occasionally becomes extremely abundant in many sections of the United States. The sexed forms appear early in autumn, and eggs are deposited in enormous numbers upon the bark. In Plate XV., Fig. 1 represents the winged male; 2, the apterous viviparous female which resembles externally the oviparous form; and 3, the eggs. The two first are much magnified.

Some of the aphides affecting herbaceous plants complete their yearly cycle upon them. The large reddish brown species (*Nectarophora rudbeckiæ*) so commonly found upon composite plants of the genus Solidago and Lactuca is one of these. In studying its autumn history in Illinois a few years ago, I found that the sexed forms developed during October, the males having wings. Eggs were occasionally deposited upon the old stems of wild lettuce (*Lactuca canadense*), but much more commonly upon the under leaf surface of the young, first-year plants of Lactuca and the closely allied Muhlenbergia. Evidently the chances of survival and future development are better in the case of the eggs deposited upon the leaves of young biennials or perennials, than of those fastened to the old stems, which are liable to be broken off and blown or washed away, so that if the eggs survived, the young aphides would not be likely to find suitable food at hand. In such cases a system of natural elimination must tend toward the preservation of the forms ovipositing upon the young plants.

Perhaps the most remarkable fact connected with the hibernation of aphides is that of the preservation of the eggs through the winter in the nests of ants. This was discovered long ago by Huber, and has since been abundantly confirmed by Schmarda, Lubbock and others. Huber's account is so interesting, and apparently so little known, that I quote it at some length:[1]

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[1] *The Natural History of Ants*, by M. P. Huber. Translated by J. R. Johnson. London, 1820. pp. 240–245.

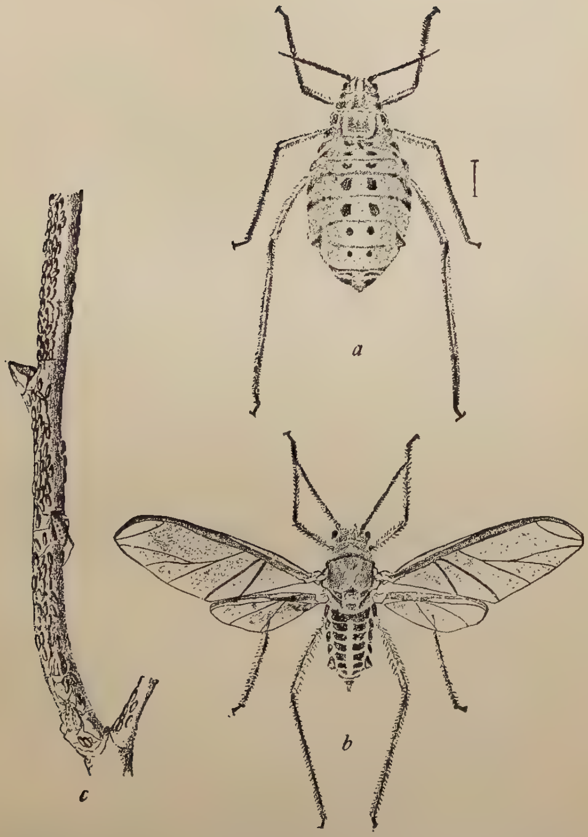

Plate XV. — The Sycamore Lachnus: *a*, Winged Male; *b*, Viviparous Female; *c*, Eggs on Twig. *a*, *b*, Magnified.

"One day in November, anxious to know if the yellow ants began to bury themselves in their subterranean chambers, I destroyed with care one of their habitations, story by story. I had not advanced far in this attempt, when I discovered an apartment containing an assemblage of little eggs, which were for the most part of the color of ebony. Several ants surrounded and appeared to take great care of them, and endeavored, as quickly as possible, to convey them from my sight. I seized upon this chamber, its inhabitants, and the treasure it contained.

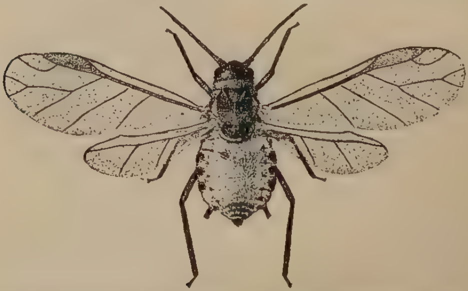

FIG. 84. — Corn Root Aphis: winged viviparous female. Magnified. (After Forbes.)

"The ants did not abandon these eggs to make their escape; a stronger instinct retained them. They hastened to conceal them under the small dwelling which I held in my hand, and when I reached home I drew them from it to observe them more attentively. Viewed with a microscope they appeared nearly of the form of ants' eggs, but their color was entirely different. The greater part were black; others were of a cloudy yellow. I found them in several ant-hills, and obtained them of different degrees in shade. They were not all black and yellow; some were brown, of a slight and also of a brilliant red and white; others were of a color less distinct, as a straw color, grayish, etc. I remarked they were not of the same color at both extremities.

"To observe them more closely I placed them in the cover of a box faced with glass. They were collected in a heap like the eggs of ants. Their guardians seemed to value them highly; after having visited them they placed one part in the earth, but I witnessed the attention they bestowed upon the rest: they approached them, slightly separating their pincers; passed their tongue between each, extended them, then walked alternately over them, depositing I believe a liquid substance as they proceeded. They appeared to treat them exactly as if they were the eggs of their own species; they touched them with their antennæ, and frequently carried them in their mouths. They did not quit these eggs a single instant; they took them up, turned them, and after having surveyed them with affectionate regard conveyed them with extreme tenderness to the little chamber of earth I had placed at their disposal. They were not, however, the eggs of ants; we know that these are extremely white, becoming transparent as they increase in age, but never acquire a color essentially different. I was for a long time unacquainted with the origin of those of which I have just spoken, and by chance discovered that they contained little aphides; but it was not these individual eggs I saw them quit, it was other eggs which were a little larger, found in the nests of yellow ants, and of a particular species. On opening the ant-hill I discovered several chambers containing a great number of brown eggs. The ants were extremely jealous of them, carrying them away, and quickly, too, to the bottom of the nest, disputing and contending for them with a zeal which left me no doubt of the strong attachment with which they regard them.

“Desirous of conciliating their interests as well as my own, I took the ants and their treasure and placed them in such a manner that I might easily observe them. These eggs were never abandoned. The ants took the same care of them as the former. The following day I saw one of these eggs open, and an aphid fully formed, having a large trunk, quit it. I knew it to be an aphid of the oak; the others were disclosed a few days after, and the greater number in my presence. They set immediately about sucking the juice from some branches of the tree I gave them, and the ants now found within their reach a recompense for their care and attention."

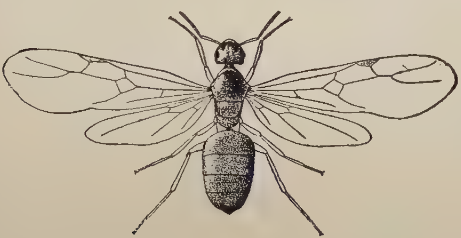

FIG. 85.—The Small Brown Ant: female. Magnified. (After Forbes.)

This recompense consisted in the liquid "honey-dew" excreted by the aphides.

Huber following Bonnet thought that these aphid eggs consisted simply of a pellicle containing a developed aphis; that "the insect in a state nearly perfect quits the body of its mother in that covering which shelters it from the cold in winter, and that it is not as other germs are, in the egg surrounded by food, by means of which it is developed and supported." But this is erroneous, as these are true eggs, a fact which has already been pointed out by Lubbock and many other naturalists.

A species of aphis living upon the English daisy was found by Sir John Lubbock to deposit, in autumn, eggs upon the leaf-stalks. These eggs were taken by the common yellow ants to their formicaries, where they were "tended by them with the utmost care through the long winter months, until the following March, when the young aphids which hatch are brought out and again placed upon the young shoots of the daisy." This eminent naturalist adds: "This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter; but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer, a case of prudence unexampled in the animal kingdom."

The instances above cited relate to aphides living upon plants outside of the nests of the ants. But there are certain species living under ground in care of the ants, whose eggs are similarly tended. For many years an insect called the Corn Root Aphis (*A. maidi-radicis*) was destructive to Indian corn in many of the western states. It was found from spring to autumn upon corn roots, always tended by the little brown ant (*Lasius niger alienus*), which dug channels for it and cared for it in every way. The winter history of this aphis had proven a decided enigma to entomologists. No one had been able to find it during winter in any stage. Some years ago, while investigating this subject under the direction of Professor S. A. Forbes, one day late in April, I came across a mass of aphid eggs in a nest of the ant just mentioned — the formicary occurring in an old corn-field in central Illinois — which were carried to the State Laboratory of Natural History. They hatched the next day into aphides that subsequently developed into the species in question. Many similar observations were afterwards made, at the conclusion of which I summarized the life history of the insect as follows:

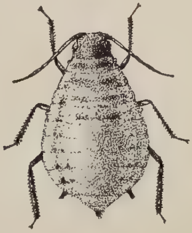

FIG. 86. — Corn Root Aphis: oviparous female. Magnified. (After Forbes.)

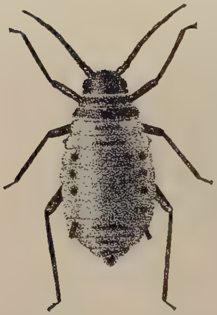

FIG. 87. — Corn Root Aphis: male. Magnified. (After Forbes.)

During the first warm days of spring, usually before the ground is ploughed, there hatch from the eggs small greenish lice that are transferred by the ants to the roots and radicles of Setaria and Polygonum, where they are carefully tended by the ants. In about a fortnight these young have become adult stem-mothers and give birth to quite a number of young. In the meanwhile the ground has probably been ploughed, and some crop sowed. In case this crop is corn the ants transfer the lice to the corn roots; but if it is oats or wheat, they may continue to rear the lice on Setaria and Polygonum. The young from these stem-mothers become adult in about a fortnight, some of them being apterous and others winged. The winged specimens fly to other hills either in the same or neighboring fields, where the ants are waiting to receive them, and proceed to establish colonies. This second generation brings forth viviparous young (mostly wingless); and generations of viviparous females continue to develop on

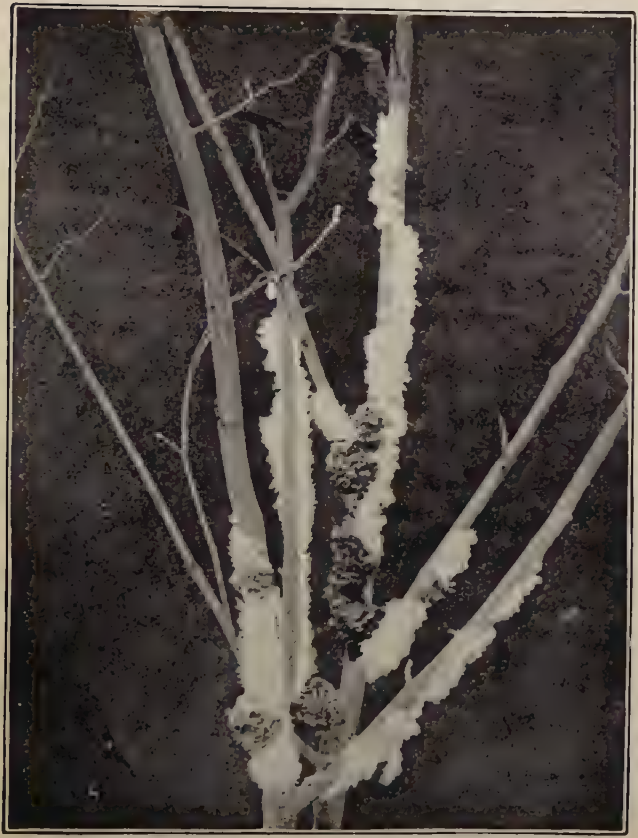

PLATE XVI.—THE WOOLLY ALDER APHIS.

corn roots throughout the summer. In autumn the true sexes are produced (both being apterous), and the eggs are deposited by the oviparous females in the mines of the ant colonies. These eggs are cared for by the ants through the winter, and the young lice that hatch from them in spring are provided for as already described.[1]

While the above observations are sufficient perhaps to indicate that the great majority of aphides spend the winter in the egg state, it is by no means true that they all do so. There are many species in which so far as we can judge no sexed individuals or eggs are ever developed. One of these, which is often extremely abundant on the branches of alders in New England, is the Flocculent Aphid (*Pemphigus tessellata*). This insect abounds throughout the summer months in the condition of parthenogenetic females; and in autumn enormous numbers of little aphides are produced. These migrate down the branches and trunk to the bases of the shrubs, where on the larger roots or among the leaves and rubbish they settle down for the long and dreary New England winter. No doubt millions of them perish or are washed away, but in spring those that are left crawl up the alder stems, and finding satisfactory positions insert their beaks through the bark and begin to feed and grow. In a short time they mature and give birth to young. They secrete a large amount of flocculent material, causing affected branches to appear as if covered with a cottony vegetable growth. They are not usually attended by ants, and the large amount of "honey-dew" they excrete encourages the growth of a black fungus.

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[1] Bulletin Illinois State Laboratory of Natural History, Vol. III., art. 3.

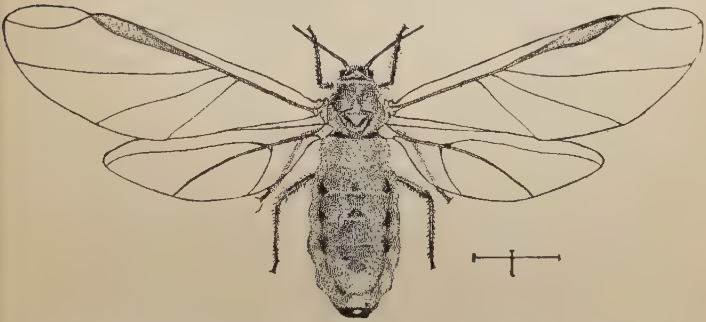

FIG. 88.—Woolly Aphis of Beech: winged viviparous female. Magnified.

There is a closely related Woolly Aphis[1] often found in colonies on the branches of the beech, which I presume passes the winter in a similar manner. In central Ohio a few years ago, I examined many colonies of these aphides early in November, finding only winged viviparous females (Fig. 88) and the last nymph stage (Fig. 89) of the same form present.

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[1] *Pemphigus imbricator.*

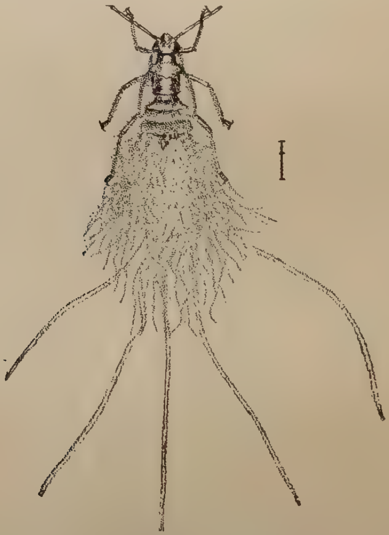

FIG. 89.—Nymph of Woolly Aphis of Beech. Magnified.

It has already been explained that the divers methods of hibernation adopted by the aphides may be explained by the principles of natural selection. With these insects we have all the essentials for the working of the method of elimination which permits only the fittest to survive. Individuals are produced in such enormous numbers that a large proportion of them may well be sacrificed without injury to the species.

The habit of migrating in summer from trees to herbs may also be explained in a similar manner. By so migrating the aphides obtain at least three important advantages, viz.: (1) escape from enemies; (2) more succulent food; (3) lessening the injury to their host-plant, or even saving it from destruction. By returning to the trees when the herbs begin to die, they find a comparatively safe place for the deposition of their eggs. In both the spring and autumn migrations there would be opportunity for the laws of natural selection to operate.

To bring out more clearly the bearing of the laws of natural selection upon the facts of aphid hibernation as we find them to-day, we will briefly review the methods outlined in the previous pages and apply these principles to each.

For our present purpose Professor Lloyd Morgan's term "natural elimination"[1] is more lucid than Darwin's "natural selection." Reduced to its simplest form this theory rests upon the fact that "in every generation of every species a great many more individuals are born than can possibly survive; so that there is a perpetual battle for life going on among all the constituent individuals of any given generation. Now in this struggle for existence, which individuals will be victorious and live? Assuredly those which are best fitted to live: the weakest and least fitted to live will succumb and die, while the strongest and best fitted to live will be triumphant and survive."[1]

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[1] *Animal Life and Intelligence*, p. 80.

Among the lower animals it often is not so much a struggle between the individuals of a species, as it is with other species and the natural conditions of existence; not so much a matter of what Morgan calls selection proper, — involving the element of individual or special choice, — as it is a matter of natural elimination. "And the factors of elimination are three: first, elimination through the action of surrounding physical or climatic conditions, under which head we may take such forms of disease as are not due to living agency; elimination by enemies, including parasites and zymotic diseases, and thirdly, elimination by competition."[2]

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[1] Romanes, *Scientific Evidences of Organic Evolution*, p. 3.

[2] Morgan, *l.c.*, p. 80.

In applying these factors to explain the hibernation of aphides we must bear in mind the prodigious powers of multiplication possessed by these insects, — because of which the autumn progeny of a single stem-mother may amount to millions of individuals. We must also remember that on account of the crowding caused by this rapid rate of multiplication, it must often happen that the oviparous females are compelled to deposit their eggs in all sorts of situations upon the food-plant; and that to-day, even when no crowding occurs, the oviparous females often exhibit a considerable diversity in habits of oviposition.

The eliminating agencies with which most aphides in their hibernating condition have to contend appear to be chiefly confined to the action of climatic conditions and natural enemies. A large proportion of the eggs deposited upon smooth bark without special protection must be blown off by winds, or washed away by rain or melting snow and ice. Species which, like the Oak Callipterus and the White Pine Lachnus, live upon trees the leaves of which remain upon the branches until the following spring, have a decided advantage in oviposition, because their eggs are less exposed to dangers of this kind than those which are simply consigned to the bark. This is particularly true of the oak species, the eggs of which are much more snugly ensconced than those of the Pine Lachnus. In the case of many bark-depositing species, which develop on the leaves, it is easy to see that the elimination of the unfit is still taking place, and that of individuals there is an enormous waste which might be saved by a more perfectly developed old-fashioned "instinct." The Apple Aphis, for example, perishes in great numbers every autumn by the falling of leaves containing developing colonies of the oviparous form; such leaves not only bear immature specimens of this form, but often also adults which have not migrated to the twigs with sufficient promptness. This loss is due largely to the lateness of the arrival of the return migrants to the apple foliage, and would be to a considerable extent at least prevented by the earlier development of the latter upon their summer host. The oviparous forms also exhibit even now considerable diversity in sites chosen for oviposition: many eggs are deposited upon smooth bark, although the great majority are placed about buds or in the interstices of rough bark. The action of elimination must evidently tend toward the preservation of the latter and the destruction of the former.

The case of the Beech Phyllaphis described above is evidently an illustration of a much more perfectly developed instinct than is exhibited by the ordinary twig-depositing species. In this case each egg is carefully placed in a specially chosen site, and is then not only securely fastened in position, but also concealed from view.

The four species of Melanoxanthus mentioned on preceding pages as living upon willow twigs furnish an interesting illustration of the gradual perfection in habits of oviposition in species of one genus. The first species (*M. salicti*) oviposits on smooth bark and about the buds, eggs being developed in great numbers. The second species (*M. bicolor*) confines itself as a rule to the region of the buds; in both these the eggs are plain black with no protective covering. In *M. salicis* a decided step in advance has been taken: the oviparous forms congregate upon the gray bark of the trunk and larger branches and deposit their eggs side by side over a considerable area. The sticky covering with which most aphid eggs are provided when first extruded is here abnormally developed. It serves to hold the eggs more firmly in place and also, on drying, leaves a thin gray coating which gives an appearance so similar to the surrounding bark that the eggs are visible only by the closest scrutiny. In *M. flocculosus* this is carried a step farther, the protective covering being more perfectly developed and the insects apparently choosing rougher bark where there are more interstices in which to conceal the eggs.

It is less easy to account for the origin of the method of hibernation adopted by those species whose eggs are kept through the winter by ants in their nests. It seems most probable that the ants first acquired the habit in the case of the underground species like the corn root aphis. The oviparous females of this form wander through the galleries of the formicary, occasionally extruding an egg, and then die. Of course any suggestions as to how the first eggs came to be carried through the winter can only be speculative. It apparently is not impossible that the ants noticed some quality about the eggs as they were first extruded which led to their recognition as a part of the food-giving pets; or possibly the first eggs were overlooked and allowed to pass the winter where the mother aphid deposited them, and were discovered in spring at the time the aphides were hatching; or the eggs may have been first stored up for food, and the surplus left over in spring may have hatched. However the habit may have originated, it evidently is so useful to all that it would be fostered. Having once become an established routine of the ants' yearly cycle, it is not difficult to imagine that they would recognize the eggs of aphides living above ground, especially those living in covered outside tunnels of the ants, and thus gradually develop the habit of carrying the eggs in and the resulting young out.

Passing now for a moment to the group of aphides whose hibernating condition is exemplified by the Woolly Aphis of the alder (p. 236), it is easy to see how natural elimination may have brought about the existing conditions. This species appears never to develop any eggs: consequently it must pass the winter in some living stage. The colonies of viviparous forms are constantly bringing forth multitudes of living young, which of course are more abundant in autumn than at any other season. The crowding produced by numbers would often compel them to wander over all parts of the shrub. Those reaching late in autumn the bases of the main stems would stand a much better chance of surviving the effects of wind, snow, rain, and ice than those on other parts of the tree. This constant elimination of the unfit and the "inherited memory" of the fit would lead to present conditions.

An idea of the rapidity of the rate of increase of aphides, and consequently the ability of a given species to withstand an enormous amount of destruction through elimination, may be obtained from an estimate made by Professor S. A. Forbes. A single stem-mother of the corn root aphis brings forth twelve to fifteen young, that mature in a fortnight. "Assuming the correctness of the figures here given as to the normal rate of multiplication and the number of generations produced in a year, and further, supposing that all the plant-lice descending from a single female hatched from the egg in spring were to live and reproduce throughout the year, we should have coming from the egg the following spring nine and a half trillion young. As each plantlouse measures about 1.4 mm. in length and .93 mm. in width, an easy calculation shows that these conceivably possible descendants of a single female would, if closely placed end to end, form a procession seven million eight hundred and fifty thousand miles in length; or they would make a belt or strip ten feet wide and two hundred and thirty miles long."

THE GROUND-SPIDERS

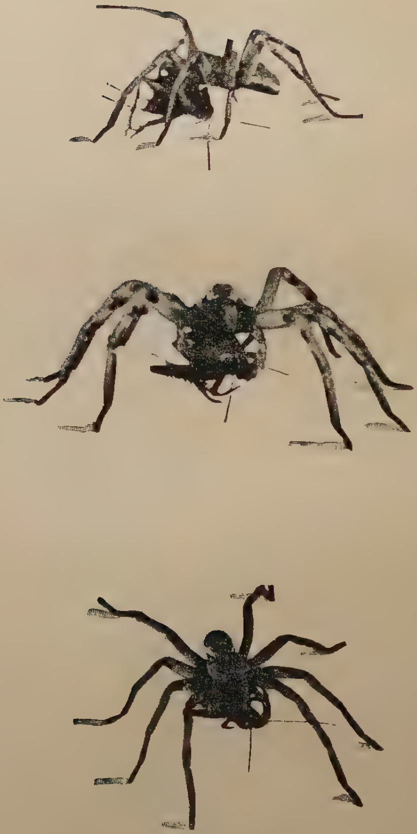

Plate XVII.—Ground-spiders feeding upon a Cricket.

THE GROUND-SPIDERS

One day early in October a large grayish-drab spider was found in a house attempting to climb the attic stairs. It had reached the second story and apparently desired to ascend to the third; but instead, it was trapped in a box and assigned commodious quarters in a large glass jar.

The captive was recognized as one of the ground-spiders of the family *Lycosidæ*, and belonged to the typical genus Lycosa. Under natural conditions out-of-doors I had seen these spiders eating a variety of insect food, so it seemed probable his spidership would not be over-fastidious in confinement. I soon found that crickets were especially esteemed, and fed him these chiefly. If he had not broken his fast for several days, the poor cricket, after entering the jar, had short shrift; the spider would pounce upon it like a flash, and the victim was held in the palpi up to the mouth, where its body-juices were eagerly sucked. So intent was the spider upon his meal that there was little difficulty in photographing him in the act, even when the conditions of light required an exposure of more than half a minute. Ordinarily he would stand on all eight legs, with the body somewhat elevated, manipulating the cricket with the palpi: such positions are represented in the middle and upper illustrations of Plate XVII. If disturbed during the meal, the spider would raise one or both of his front legs and wave them up and down so slowly that they show the motion in the upper photograph.

During the summer and autumn months, one can very commonly find in fields, holes which descend more or less vertically into the ground. Some have no special barrier around the entrance, while others are provided with a miniature turret composed of leaves or grass and sticks fastened together by silken threads. An idea of the appearance of these turrets may be obtained from the accompanying figure. Should you carefully dig out some of these holes, you would be likely to find at the bottom a large ground-spider similar to the one already discussed. Several species of these Lycosas excavate tubular holes in the ground for protection and concealment as well as for

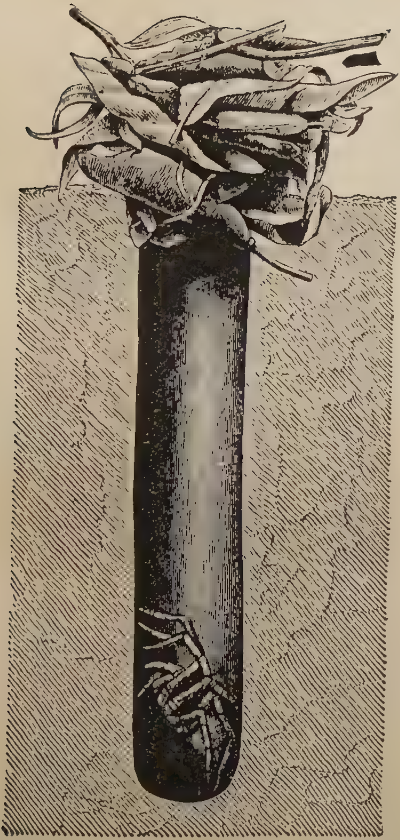

Plate XVIII. — Turret-spider in Burrow.
(After Emerton.)

brooding-chambers for the eggs. Sometimes a large female spider will be found at the bottom of the tunnel with a good-sized cocoon containing a batch of eggs beneath her. When these eggs hatch, the young spiders crawl upon the mother's back, and thus ride about with her when she wanders around in search of food. In a short time, however, they leave her and shift for themselves: the young of certain species living in sandy situations excavate holes for themselves soon after leaving the mother, while others apparently live upon herbage and bushes for some time before adopting the burrowing habit.

Various observers have found that several species of these ground-spiders may readily be kept in confinement, and fed upon flies, grasshoppers, crickets, and other insects. An excellent method is to place the spider in a candy-jar eight or ten inches high, nearly filled with earth, and having a little moss on the surface. Some spiders will readily construct homes in this earth, and furnish abundant opportunity for interesting observations.

A LONG-LEGGED RACE

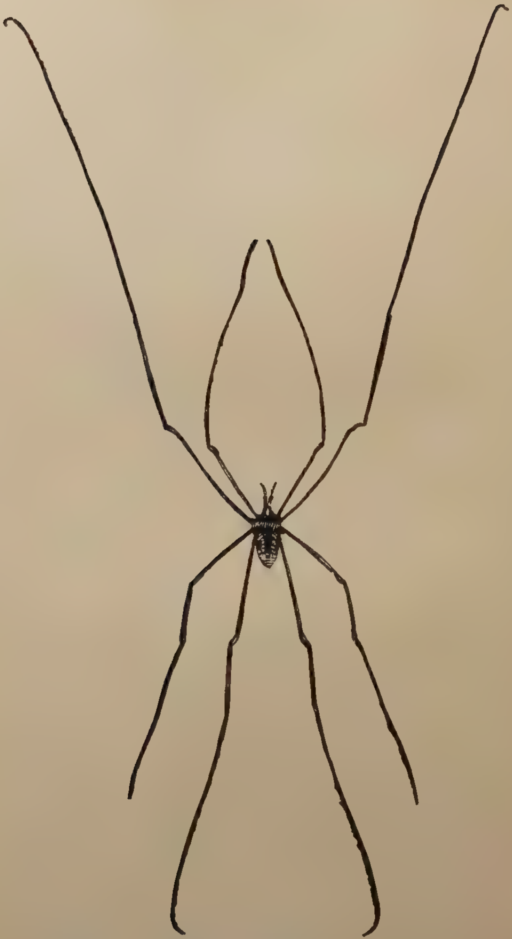

Plate XIX.—Striped Harvest-spider. Male Southern Form.

A LONG-LEGGED RACE

There are few common creatures about which so little is really known by the general public as the group of harvest-spiders commonly known in America as "daddy-long-legs." In Europe this name is given to the crane-fly, an entirely different animal. In some parts of America the harvest-spiders are called "grab-for-gray-bears," and various other odd names are occasionally applied to them.

These harvest-spiders are neither insects proper nor true spiders, although they are related to both groups. They belong to a family known technically as *Phalangiidæ.* The eight long legs are attached to a body which appears in comparison grotesquely small. The body consists of two parts closely united, as may be seen in Fig. 90 *a.* The front portion is the cephalothorax, or head and thorax combined, and the hind portion is the abdomen. Projecting from the cephalothorax are two palpi (*d*) which are used as feelers and to catch prey; and on top of the cephalothorax is a peculiar tubercle, on each side of which is a single rather large eye (*b*, *c*). This tubercle is called the "eye-tubercle" or "eye-eminence." Each palpus is tipped with a claw which is sometimes pectinated on its inner edge and sometimes is smooth.

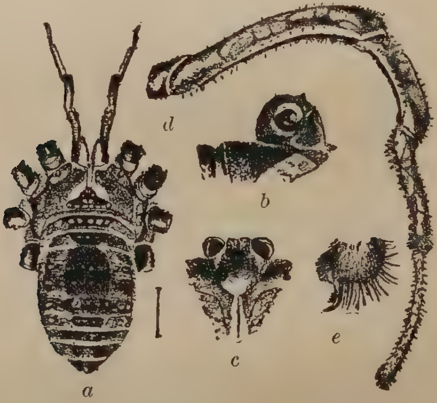

Fig. 90.—Structural Details of a Harvest-spider: *a*, body, with legs removed; *b*, eye-tubercle, side view; *c*, eye-tubercle, front view; *d*, palpus; *e*, claw of palpus. All magnified.

In the United States the family of harvest-spiders is a comparatively small one, it being generally difficult to find a dozen species in a given locality. Most of the species have a wide range. As a whole these creatures are beneficial to man, feeding on plant-lice and other insects.

The eggs are deposited in the ground, a short distance from the surface.

The harvest-spider most familiar to many people probably is the ash-gray species described by Wood as *Phalangium cinereum.* This is the form most commonly found about houses, barns, and neglected board-piles. It is rare in the fields and woods; and as its color specially fits it to live upon weather-beaten boards, we may consider it the most domestic of our various species. Its back is of an ash-gray color, more or less mottled with brownish blotches, and the long legs are brownish. Unless disturbed it is generally quiet during the day, but on cloudy days and at dusk it moves about quite rapidly. It apparently feeds on the small

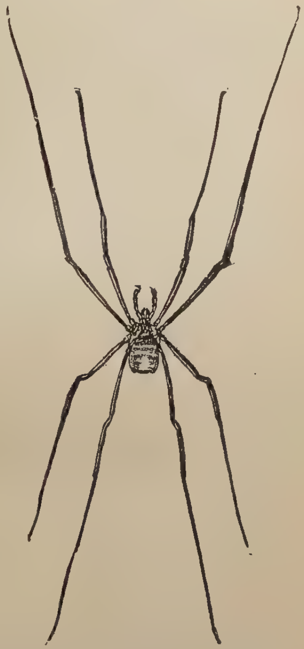

Fig. 91.—The Ash-gray Harvest-spider.

flies and other insects that it finds during its rambles. It passes the winter in the egg state, hatching in spring and becoming full-grown early in summer.

What this Ash-gray Harvest-spider is to the vicinity of buildings the Striped Harvest-spider[1] is to the fields and woods. This species is especially characterized by the black stripe upon the brown body — more marked in the male than in the female. This abundant form passes the winter in the egg state, hatching late in spring into little creatures that live amid grasses, low herbage, and rubbish piles, foraging on such minute insects as they can find. They grow slowly, maturing toward midsummer, when the adults are to be found everywhere — on bushes and trees in the woods, in meadows and pastures, along fences, and often in sheds and outhouses. In the prairie regions of the Mississippi Valley they abound in the cornfields during

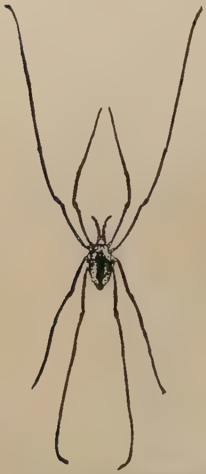

FIG. 92. — The Striped Harvest-spider. Male.

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[1] *Liobunum vittatum* Say.

the month preceding full growth, where they feed upon aphides and other insects.

The Polished Harvest-spider[1] is one of the prettiest species of the family. Its body is less than one-fifth of an inch long, and the second legs measure about two inches. The males are of a clear reddish-brown color, with dark brown or blackish legs.

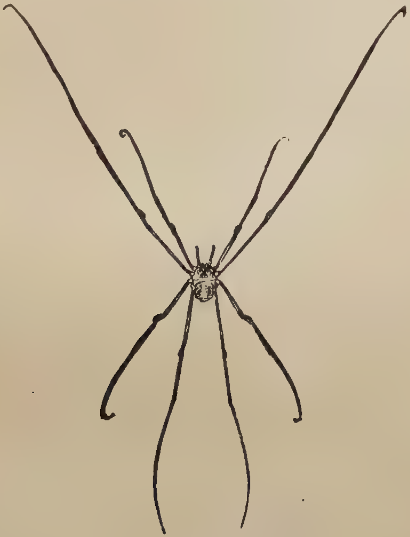

FIG. 93.—The Polished Harvest-spider. Male.

The eye-tubercle is rather prominent, slightly constricted at the base, black above, with a longitudinal depression between the eyes, and a regular curved series of small, acute, black spines over each eye. The palpi are slender with the joints slightly arched and furnished with many small tubercles and hairs. The females have a longer, rounder body than the males, and there is usually a dark-colored longitudinal marking on the back.

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[1] *Liobunum politum* Weed.

This species is found from New England west to the Valley of the Mississippi, and south at least to the Ohio River. It is an out-door creature, commonly occurring in meadows and pastures or among shrubbery; I have found it especially abundant along the margins of small streams. It becomes full-grown about midsummer, and is present until early in autumn. In vivaria these harvest-spiders greedily devour plant-lice.

In the southern states there is occasionally found a form very similar in structure to this species, but much larger in size. It appears to be simply the southern representative of the northern form.

With one exception, all the northern species of harvest-spiders pass the winter in the egg state. The Cinnamon Harvest-spider,[1] however, hatches from the egg late in summer or early in autumn and becomes about one-third grown before winter. It then hibernates beneath boards, logs, or other shelter, and completes its growth the following spring. The legs of this species are very long for the size of the body, and both body and legs are of varying shades of cinnamon brown. (Plate XXI.)

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[1] *Liobunum ventricosum* Wood.

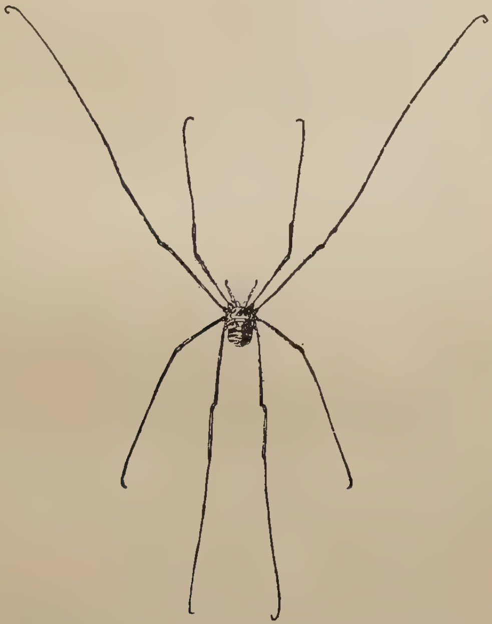


FIG. 94.—The Black-legged Harvest-spider. Male.

The Black-legged Harvest-spider is a handsome species found in Ohio and adjacent states. The male has a clear reddish-brown body with blackish legs, while the female has a darker body and lighter legs. It matures early in summer and in some seasons is quite abundant.

From a biological point of view, one of the most interesting facts concerning these harvest-spiders is that of their remarkable geographical variations. On account of the comparative simplicity of their structure, they offer a good opportunity to determine the effect of the varying conditions found in different latitudes upon the life of invertebrate animals. Like other arachnids these harvest-spiders undergo no definite series of transformations; they simply moult or cast their skins as increase in size requires. Consequently, it would seem likely that they would show the results of the vicissitudes of existence.

This geographical variation is well illustrated by the Striped Harvest-spider. In the north, and especially in the plain region of Dakota, the body is rather small and the legs very short. As one goes south, the size of the body and the length of the legs gradually increase, until in

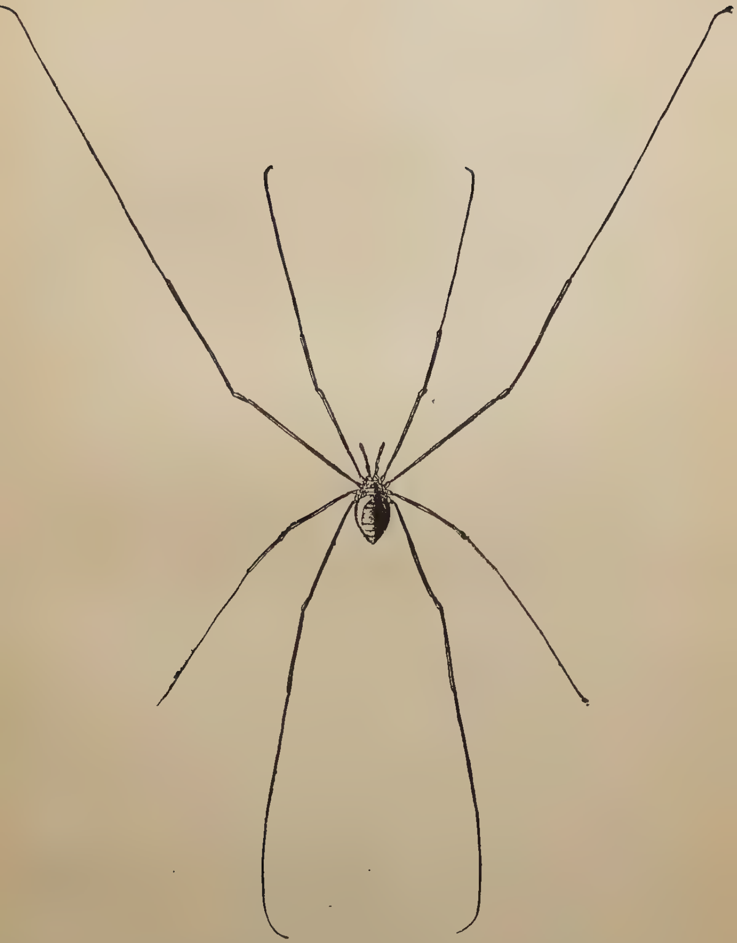
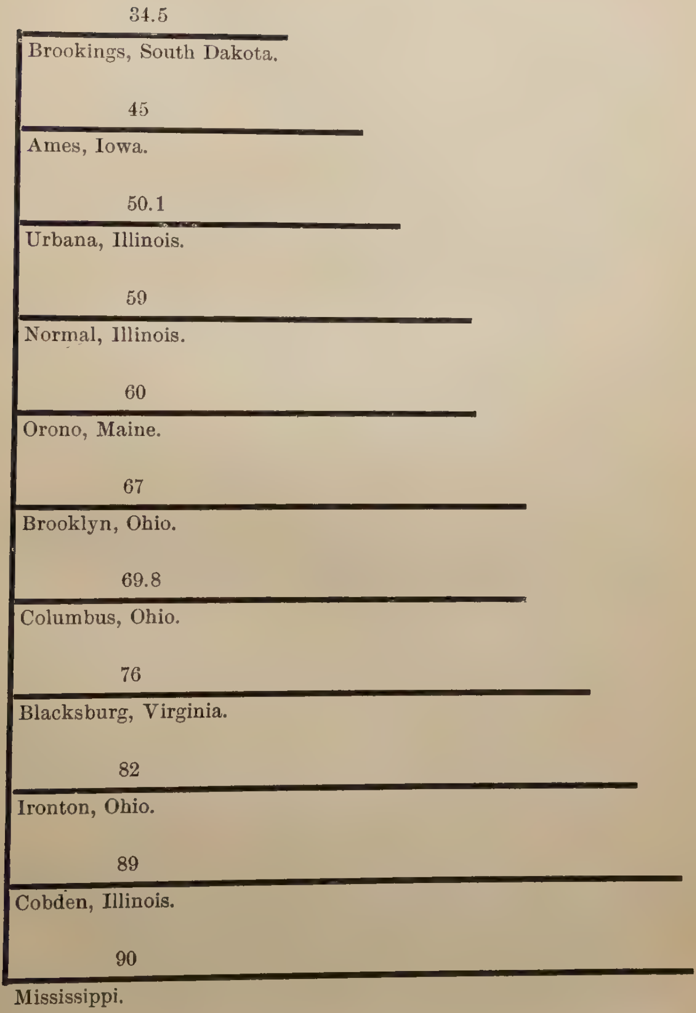


PLATE XX.—STRIPED HARVEST-SPIDER. FEMALE. SOUTHERN FORM.

Mississippi one finds a harvest-spider with legs nearly three times as long as in the Dakota specimens. These northern and southern forms were originally described as different species, but in a long series of specimens from many different regions I can find no dividing line between the two. In the diagram on the following page I have reduced the lengths of the second pair of legs of the specimens from all the localities there named to straight lines, each line representing the precise length, and the figures above it showing its measurement in millimeters. Where more than one specimen has been measured from a given locality, the average is taken. The difference in the progressive lengthening from the north to the south is in no case greater than has been found to occur in a single locality. It is an evident and remarkable instance in which differences of conditions have produced an effect on the size of the organism. Some idea of the difference in leg development may be obtained by comparing Fig. 92, which represents a northern form, with Plate XIX., showing the southern variety, although the latter has not such long legs as are often found. The female of this species attains even a greater size (Plate XX.).


34.5
Brookings, South Dakota.
45
Ames, Iowa.
50.1
Urbana, Illinois.
59
Normal, Illinois.
60
Orono, Maine.
67
Brooklyn, Ohio.
69.8
Columbus, Ohio.
76
Blacksburg, Virginia.
82
Ironton, Ohio.
89
Cobden, Illinois.
90
Mississippi.

The Cinnamon Harvest-spider shows nearly as great a geographical variation as does its striped relative. Southern forms of this species have the legs twice as long as New Hampshire specimens, and all gradations may be found between the two. There is a gradual increase in length of legs and size of body as one goes southward.

The variation of the harvest-spiders is not confined to different regions: in a given locality there may be found a decided variation in size of body and length of legs in mature individuals of the same species and sex. In a series of a hundred such specimens taken at random the body of the largest individual will usually be from one-fifth to one-fourth longer than that of the smallest, and the legs will vary even more.

Among the factors which may have led to the larger size of the southern forms it seems to me that the following may be of importance:—

(1) The direct effect of a long, warm period of growth, with abundant food, upon the individual before attaining its complete development.

(2) The effect of a long period of development of the eggs in the ovaries of the female.

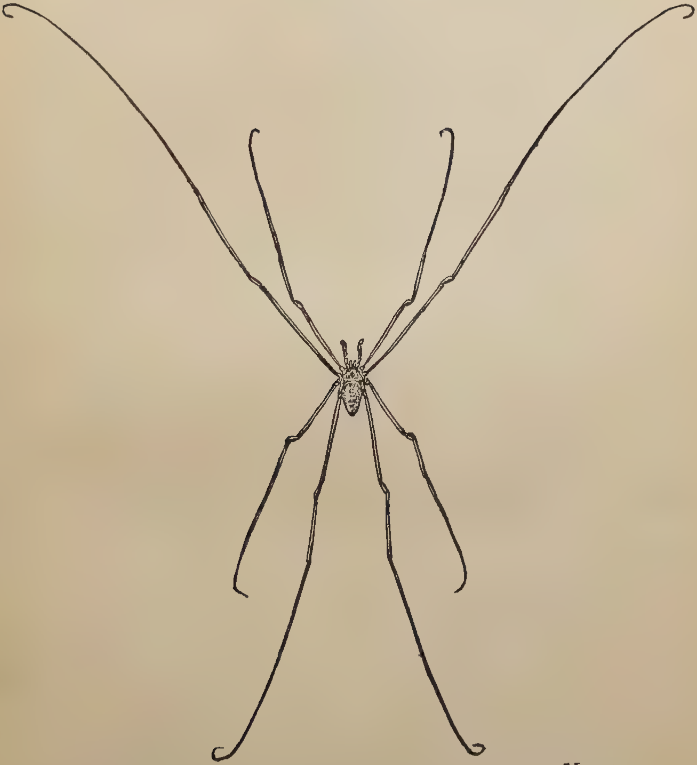


Plate XXI. — The Cinnamon Harvest-spider. Male.
Southern Form.

(3) By the action of the eliminating principle in natural selection in fostering those individuals which attain the maximum size compatible with their environment. This increase in size may possibly be of benefit to the species by enabling it to prey upon larger insects, thus increasing the source and variety of its food supply, and by enabling it better to elude predaceous enemies or to catch fleeing prey.

Apparently the harvest-spiders have to contend with comparatively few enemies. The silk-spinning spiders are among the most destructive of these. The long legs of the "daddies" often become inextricably entangled in spiders' webs, leading to the death of the individual. These creatures are also often devoured by birds, though the ill-smelling liquid emitted through the pores on the front of the body probably protects them to a considerable extent from such foes.

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